GENERAL SCIENCE

INTERMEDIATE: BOOK 1

J. A. PARTRIDGE

Ex libris
universitatis
albertaensis

PROVINCIAL ARCHIVES
OF ALBERTA
ACC. 73.110

Digitized by the Internet Archive
in 2017 with funding from
University of Alberta Libraries

https://archive.org/details/generalsciencefo01part

GENERAL SCIENCE

Intermediate: BOOK 1

Approved for use in the schools of Ontario.

Basic Science for Young Canadians.

GENERAL SCIENCE

For Intermediate Grades

Intermediate: BOOK 1 } by
Intermediate: BOOK 2 } J. A. PARTRIDGE

Intermediate: BOOK 3 } by H. BOWERS and
Intermediate: BOOK 4 } R. N. BISSONNETTE

GENERAL SCIENCE

INTERMEDIATE: BOOK 1

J. A. PARTRIDGE

J. M. DENT & SONS (CANADA) LIMITED
TORONTO VANCOUVER

This book is copyright. It may not be reproduced whole or in part by any method without permission in writing from the publishers.

Copyright, 1952

by

J. M. Dent & Sons (Canada) Limited

First Printing, January, 1953
Second Printing, February, 1954
Third Printing, May, 1955
Fourth Printing, September, 1955
Fifth Printing, August, 1957
Sixth Printing, January, 1959
Seventh Printing, January, 1960

Printed and Bound

by

McCorquodale & Blades (Printers) Limited
Toronto

LIBRARY
UNIVERSITY OF ALBERTA

ACKNOWLEDGMENTS

For valuable advice and assistance in the preparation of this book my indebtedness is gratefully acknowledged:

To Dr. E. W. McHenry, Chairman of the Ontario Interdepartmental Nutrition Committee, and to Mr. J. L. Van Camp, General Manager of the Canadian Forestry Association, for helpful suggestions in preparing the manuscript for the units dealing with Foods and Forestry respectively. To many other persons who have contributed to any merits this book may have, including Mr. Donald Farwell, Science Master at the Toronto Normal School, for valuable advice and assistance in our efforts to plan and prepare illustrations with appeal and instructional value to Grade Seven pupils, and those unnamed assistants without whose loyal and efficient services in research, editorial criticisms, and secretarial work this book could not have been produced.

To those individuals and organizations who have provided the photographs which introduce the various units throughout the book: Unit One, U.S. Soil Conservation Service; Unit Two, Ontario Department of Lands and Forests; Unit Three, Mr. Malak, Ottawa; Unit Four, Elizabeth Frey, Toronto; Unit Five, Giant Yellowknife Gold Mines, Ltd.; Unit Six, the U.S. Forest Service; Unit Seven, the Royal Canadian Air Force; and Unit Eight, Milne Studio Limited and *Canadian Homes and Gardens.*

To many Departments of the Government of Canada for illustrations on the pages listed: Department of Agriculture, 15, 59, 156, 275 (Division of Forest Biology, Science Service), 305; Prairie Farm Rehabilitation, 124 (upper), 376; Department of Trade and Commerce, 311; Forestry Branch, Department of Resources and Development, 255 (lower), 280; Bureau of Geology and Topography, 204, 206, 213, 218 (lower), 219 (lower), 322 (B); Bureau of Statistics, 282; Central Experimental Farm, 373; The National Film Board of Canada, 5, 18, 29, 73, 92 (right), 133, 157 (upper), 167, 205, 227, 240, 242, 244, 255 (upper), 276, 281, 308, 313, 330, 375 (B), 394.

To various branches and departments of provincial governments: Ontario Department of Lands and Forests, 259, 261, 273 (left), 278 (right), 286, 293; Ontario Department of Agriculture, 378, 399; Alberta Government, 80; British Columbia Department of Education, 416; British Columbia Government Travel Bureau, 5; Manitoba Travel Bureau, 96; Conservation Branch, Ontario Department of Planning and Development, 123, 124 (lower), 125, 130, 263, 279, 296, 340; Saskatchewan Department of Natural Resources, 273 (right); Manitoba Department of Mines and Natural Resources, 283.

THERIEN S.D. 2149
THERIEN, ALBERTA

275153

To the following branches of the U.S. Government: U.S. Department of Agriculture, 50, 113, 326, 368; U.S.D.A. Soil Conservation Service, 80, 116, 118, 122, 300, 327, 338, 344, 345, 346, 347, 351, 377, 381; U.S. Forest Service, 100, 251, 271 (upper and lower), 274, 287; U.S. Department of the Interior, 322 (A); U.S. Naval Research Laboratory, 117; U.S. Weather Bureau, 91 (F. Ellerman), 92 (left, H. T. Floreen), 95 (W. A. Bentley).

To various provincial, state, city, and educational institutions as follows: The Canadian Geographic Society, 237; City of Toronto, 79; New York State College of Agriculture at Cornell University, 13, 262; College of Agriculture, University of Wisconsin, 2, 333; University of Missouri, College of Agriculture, 135; Ohio Agricultural Experiment Station, 297; Agricultural Extension Service, University of Minnesota, 372; Buffalo Museum of Science, 209, 322 (lower); Harvard University School of Medicine and Dr. Walker, 174; Cleveland Museum of Natural History, 214; Walker Museum, University of Chicago, 218 (upper); Chicago Museum of Science and Industry, 235; Pleasant View School, Milwaukee, 128.

To industrial, commercial, and business organizations, and to individuals, as follows: Abitibi Power & Paper Company, Limited, 82, 253; The Advertising Council, Inc., 272; Associated Milk Foundations, 155; Associated Screen News Limited, 239, 363; *Better Homes and Gardens* Garden Book, 63, 68, 384, 412, 414; Canada Packers Limited, 309 (A, B, D); *Canadian Homes and Gardens* Magazine, 7, 65, 400, 405; Canadian Industries Limited, 309 (C), 386, 397; Canadian Johns-Manville Co. Limited, 230; *Canadian Nature* Magazine, 9, 22, 140; Canadian Pacific Railway, 207; Canadian Pulp and Paper Association, 258; J. I. Case Co., 111, 198, 307, 314, 347, 361, 370; Comstock Publishing Company, 42; Corning Glass Works, 232; John Deere & Company, 278 (left); J. M. Dent and Sons, Limited, 252; Colin Farmer, 93; *Flower Grower* Magazine, 409; General Biological Supply House, Chicago, 164 (E), 417; Hugh M. Halliday, 164 (A, B, C, D); Biological Supply House, Chicago, 164 (E), 417; International Harvester Co., 358, 359; Verne Morton, 277; Ribelin Photo Studio, 375 (A); The Steel Co. of Canada, 236; Sunkist Growers, 157 (lower), 160; Swift Canadian Co., 310.

To various individuals, publishers, and organizations for permission to reproduce their works, literary and art, credit for which has been given throughout the book.

J.A.P.

TO THE TEACHER

This text has been prepared to present an organized body of general science that will lead pupils of Grade VII to a better understanding of the principles underlying natural phenomena and modern living conditions.

The content is based upon the Ontario Outlines of Courses for Grade VII of the Intermediate Division, and upon programmes of study drawn up by the Departments of Education of other provinces and by local curriculum committees in Ontario. Many rural schools may find it advisable to use this book and *General Science, Intermediate: Book 2,* with both Grades VII and VIII in alternate years.

To serve the varying interests of pupils in the widely differing communities throughout Canada, it has been thought wise to include a more comprehensive course of study than could be covered in one year. It is suggested, therefore, that pupils should use this book as a text to cover the core topics of a general course, and as a supplementary reader for the other topics.

The essentials of "the scientific method" have been kept in mind throughout the book. A wealth of pupil investigations, experiments, and research activities, all designed for average classroom or home conditions, have been suggested. These have been integrated with the text matter with a view to establishing basic principles of science, which frequently are reviewed and applied to new circumstances in subsequent chapters.

The importance of the conservation of natural resources — of soil, water, forests. minerals, and wildlife—has been stressed throughout the book. The objective has been to create an understanding of its need and of some methods of accomplishing it, and, more important still, a sense of responsibility to think of conservation as a way of living. Several chapters have been organized specifically to present facts and principles of science under conservation headings. Elsewhere, the conservation viewpoint has been presented at every opportunity.

It has also been the author's intention to make pupils more conscious of the interdependence of rural and urban communities, and he has endeavoured, in the chapters on agriculture, to foster a mutual respect through an understanding of the role each plays in the Canadian economy.

Sound films and film strips are listed at the end of most chapters. Many of the sound films may be borrowed by schools in Ontario, without charge, upon application to *The Visual Education Branch, Ontario Department of Education, 244 College St., Toronto.* The film strips listed are available only by purchase from the sources indicated. In provinces other than Ontario, application for a list of films and film strips should be made to the Film Library of the Department of Education.

The author will consider his efforts well repaid if this book helps the pupils to be questioners, investigators, and thinkers rather than passive acceptors of facts.

J. A. P.

CONTENTS

Acknowledgments .... *v*
To the Teacher .... *vii*
Message to Girls and Boys .... *xiii*

UNIT ONE. Plants Are Important to Man

CHAPTER PAGE

1. MAN'S DEPENDENCE UPON PLANTS *1*
    - *Plants Give Us Food* *1*
    - *Plants Give Us Shelter and Clothing* *5*
    - *Plants Beautify the Earth* *7*
    - *Plants Meet Special Needs* *11*
    - *Some Unusual Plants* *12*
    - *Some Plants Are Harmful to Man* *13*
    - *Man Makes Plants Serve Him Better* *17*

2. HOW GREEN PLANTS MAKE A LIVING *21*
    - *The Needs of Green Plants* *21*
    - *The Essential Parts of Green Plants* *25*
    - *The Work of Roots* *29*
    - *The Work of Leaves* *32*
    - *The Work of Stems* *36*
    - *Living Plants Breathe* *38*

3. PLANTS PREPARE FOR THE FUTURE *41*
    - *Plants Use and Store Food* *41*
    - *Plants Reproduce Themselves* *48*

CHAPTER PAGE

4. LET'S USE PLANTS TO BEAUTIFY OUR SURROUNDINGS 58
   - *Using Plants Outdoors* 58
   - *Using Plants Indoors* 66

UNIT TWO. Water: Nature's Great Gift

5. WATER IN OUR DAILY LIVING 73
   - *Water, Water, Everywhere* 74
   - *Water Is Essential to Life and Civilization* 76

6. THE INS AND OUTS OF WATER 88
   - *Water as a Liquid, a Solid, and a Gas* 88
   - *Water Makes Some Things Disappear* 101
   - *Hard and Soft Water* 104

7. WATER MUST BE CONSERVED 109
   - *Why Water Must Be Conserved* 110
   - *Man and Nature Can Conserve Water* 112
   - *Community Planning To Conserve Water* 126

8. WATER CONTRIBUTES TO HEALTHFUL LIVING 131
   - *Providing a Safe Water Supply* 131
   - *Bringing Water to Our Homes* 142
   - *Using Water To Dispose of Wastes* 144

UNIT THREE. Food and Healthful Living

9. WHAT SHALL WE EAT? 147
   - *Why Do We Eat?* 147
   - *What's in Our Food?* 149
   - *A Guide to Good Eating* 152
   - *Making and Keeping Our Foods Good To Eat* 161
   - *Precautions To Avoid Illness by Foods* 163

CHAPTER PAGE

10. WHAT BECOMES OF OUR FOOD? *171*
    - *Our Food Must Be Digested* *171*
    - *The Blood Absorbs Digested Food* *173*
    - *The Blood Transports Digested Food* *173*
    - *Breathing Uses Food* *174*
    - *Waste Products Are Eliminated* *175*

UNIT FOUR. Energy and Machines

11. MAGNETS HELP US IN DAILY LIVING *178*

12. MACHINES MAKE OUR WORK EASIER *188*
    - *Kinds of Machines* *189*
    - *Working with Machines* *194*
    - *Machines Improve Our Way of Living* *197*

UNIT FIVE. Rocks and Minerals Are Important to Man

13. THE EARTH'S CRUST *201*
    - *The Earth's Origin* *202*
    - *The Changing Earth* *203*
    - *New Rocks from Old* *209*
    - *The Earth's First Rocks: Igneous Rocks* *220*

14. ROCKS AND MINERALS IN MAN'S SERVICE *225*
    - *Rocks, Minerals, and Metals* *226*
    - *Rocks as Construction Materials* *227*
    - *Minerals in Daily Life* *229*
    - *Ores and Metals* *233*
    - *The Mining Industry Is Important to Us* *241*
    - *Minerals Must Be Conserved* *243*

CHAPTER PAGE

UNIT SIX. Forests Are Important to Us: Conserve Them

15. USING AND ENJOYING OUR FORESTS *249*
Forests Give Us Many Everyday Products *250*
Forests Are Sources of National Wealth *254*
Forests Conserve Wildlife and Provide for Recreation *259*
Forests Improve Climates and Water Supplies *261*

16. WE MUST PROTECT AND USE OUR FORESTS WISELY *269*
Forest Enemies *270*
Conserving Forests by Wise Management *278*

17. WE NEED MORE FORESTS AND MORE TREES *285*

UNIT SEVEN. Our Living Comes from the Soil

18. AGRICULTURE IS CANADA'S BASIC INDUSTRY *304*
Farm Products Feed the Nation *306*
Urban and Rural People Depend upon Each Other *310*
Rural and Urban Co-operation Helps To Build a Strong Nation *314*

19. SOIL, THE NATION'S BEST BANK ACCOUNT *317*
Rocks Become Soil *318*
Soil Nourishes Green Plants *326*

20. SAVE THE SOIL *336*
Erosion: Enemy of the Soil *336*
Erosion in History and in the Future *350*

CHAPTER PAGE

21. MAKE THE SOIL MORE PRODUCTIVE 357
  - *Characteristics of Good Soil* 357
  - *How Soil Loses Fertility* 363
  - *How Nature and Man Can Conserve Soil Fertility* 364
  - *How Can Farmers Make the Soil More Productive?* 369
  - *Science Helps Farmers Make Their Soil More Productive* 377
  - *Soil Fertility and Population* 378

UNIT EIGHT. Keeping Our Home and School Surroundings Useful and Attractive

22. LET'S MAKE A VEGETABLE GARDEN 383
  - *Planning the Vegetable Garden* 383
  - *Learning about Seeds and Seedlings* 387
  - *Starting the Vegetable Plants* 391
  - *Caring for the Vegetable Garden* 395

23. LET'S MAKE OUR SURROUNDINGS BEAUTIFUL 399
  - *Planning Attractive Gardens* 399
  - *Carrying Out Our Plans* 406
  - *Keeping the Yard Attractive* 410

Appendix 416

Index and Glossary 419

MESSAGE TO GIRLS AND BOYS

Are you inquisitive? Do you ask questions about the everyday things around you? Do you like to investigate, explore, experiment? If so, I should like to spend the year with you, share your explorations and discoveries, and help to answer some of your questions. Together, we could discover much of interest and of use to us in our daily work and play. It will be your teacher's privilege to experiment and explore with you, and to share the thrill of discovery. May this book help you in your efforts.

As you read the pages that follow and carry out the experiments suggested, keep in mind that you are learning in the same manner in which the great scientists of history made their discoveries. Scientists do not take the word of others; they find out facts for themselves by experiment and investigation. Some of your investigations will be made in groups; others by yourself, perhaps at home. Your teacher may assist you in making new discoveries by showing you motion pictures and film strips.

May you always retain your curiosity! The more curious you are, the more you will investigate; the more you learn of the things around you, the better scientist you will be.

I wish you and your teacher success in your voyages of exploration and discovery.

J. A. PARTRIDGE.

UNIT ONE

Plants Are Important to Man

1. *MAN'S DEPENDENCE UPON PLANTS*

Plants serve man well. They provide him with bread and meat, clothing and shelter. They beautify his surroundings and make his life more enjoyable. Through time man has learned how to make plants serve him better.

2. *HOW GREEN PLANTS MAKE A LIVING*

The earth gives plants water and air, minerals and food, light and favourable temperatures needed to live and grow. Working together, their roots, leaves, and stems enable the plants to breathe, make their food, and serve man.

3. *PLANTS PREPARE FOR THE FUTURE*

Plants work today to provide for tomorrow. They store food to satisfy future needs. They provide new plants to take their places when they are gone. Man often helps plants to carry out these activities.

4. *LET'S USE PLANTS TO BEAUTIFY OUR SURROUNDINGS*

Plants provide beauty. In summer, trees and shrubs, flowers and green grass, planted by man and nourished by Nature, make up the beauty we enjoy in parks and gardens. In winter our house plants bring a touch of summer beauty to our homes.

Before reading further in this unit, study the picture on the following page and list all the ways plants contribute to man's welfare in that scene.

1

MAN'S DEPENDENCE UPON PLANTS

HOW DIFFERENT, how impossible, our lives would be without plants!

To live, we must eat and breathe. Nearly all of our food comes directly or indirectly from plants. Bread and butter, beef and turkey, fruits and vegetables, all come from plants grown on the farm. Fish and lobsters are dependent upon plants living in water. Even the oxygen that we breathe is given to the air chiefly by green plants.

For comfort, man needs shelter and clothing. The wood in his house and the fibres in his clothes, whether they be silk, rayon, linen, or wool, come from plants. To make life richer, man enjoys the beauties of nature, her wild flowers, her trees and shrubs; he also makes and cultivates gardens to add more beauty to his environment.

Yes, most of the necessities and luxuries of life are provided by green plants and their products.

Plants Give Us Food

WE EAT PLANTS AND PLANT PRODUCTS. Among the most important food plants cultivated by man are wheat, corn, rice, and potatoes. The wheat crops of the Canadian West have earned for it the title, "the bread-basket of Canada". In the northern plains of the Central United States, in Russia, in India, and in Argentina wheat is likewise an important source of food and wealth. It was introduced from Western Asia to Northern Africa, then to Europe, and later to Canada and the United States of America. Throughout the centuries, wheat has been one of man's most highly prized foods.

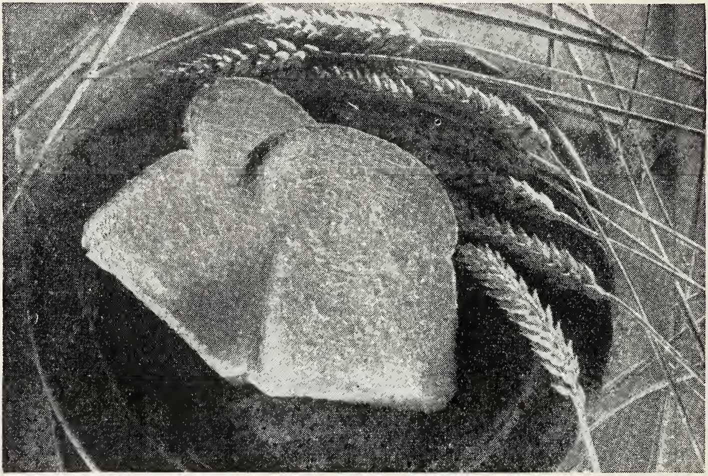


FIG. 1-1. WHEAT, THE PLANT THAT FEEDS THE WORLD, GIVES US OUR DAILY BREAD.

Corn has long been the chief food of millions of people — of the early Aztecs, the Incas of Peru, and the North American Indians. It is still the main source of wealth in the Corn Belt of the United States. Hundreds of millions of people in the Far East have for centuries depended upon rice as their main food. Potatoes have long been the staple food of many peoples. So important were they in Ireland a hundred years ago that one crop failure led to famine and the migration of thousands of people to America.

Many other plants provide man with food. Barley, rye, and oats have been the chief grain foods in several parts of Europe and Asia. Vegetables are an important part of every dinner. Fruits of garden and orchard, of tropical and temperate climates, have long provided a large and a healthful part of man's food. Sugar, from sugar cane in the Tropics and from the sugar beet of temperate regions, becomes an important part of many of our foods. In the tropics the palm trees alone provide coconuts, edible oils, sago, sugar, and beverages. In fact, the forward march of civilization has depended upon improvements in the cultivation of plants.

OUR MEAT COMES FROM PLANTS. Plants make possible meat and fowl, butter and cheese, eggs and fish, all of which are important in our diet. The animals that provide these foods get their nourishment from plants. Our domestic animals feed upon grasses, grains, and root plants, then manufacture the useful parts of these into flesh, milk, and eggs. The game birds and fish which become delicacies on our tables derive their food from plants on land or in water.

All parts of plants contribute to our food, either directly or through the animals which feed upon them. We derive nourishment from the roots of carrots, beets, and radishes; from fruits such as grapes and berries, apples and pears, melons and pumpkins, peas and beans, and the various grains; from the leaves of such plants as lettuce and cabbage; and from the stems of asparagus, sugar cane, and sugar maple. Our domestic animals eat such feeds as the roots of turnips, the stems of corn plants, the leaves of clovers and grasses, and the fruits of grains. Then we eat their flesh.

Truly, without plants man could not eat; hence he could not live.

For Investigation and Report to Class

Name the plant sources for each of the following and describe how it is made ready for human consumption: cocoa, chocolate, tapioca, macaroni, sugar, coffee, ice cream, oysters.

A Class Chart

Make a table headed *Plants Give Us Food,* and ruled into columns labelled: *Roots, Stems, Leaves, Flowers, Fruits, Seeds.*

In each column name several kinds of plants.

STORING VEGETABLES FOR WINTER. Vegetables for winter use must be preserved in such a manner that they will not decay, but will retain their freshness, flavour, and food value. This may be done either by canning or by storing them.

Beans, peas, spinach, sweet corn, and tomatoes may be canned at home or in factories. The vegetables, whole or in pieces, are heated to a temperature high enough to kill all germs. While still hot, they are sealed in cans or jars to keep other germs from entering.

It is cheaper to store beets, carrots, cabbages, onions, potatoes, pumpkins, and squash than to can them. Most of them keep their flavour better, too, when stored. Only vegetables that are firm and free from bruises, cuts, cracks, and disease should be selected. The storage place must not be dry enough to cause the vegetables to wilt, nor moist enough to cause decay. Beets, carrots, potatoes, parsnips, and turnips should be stored in tight-sided containers, covered with dry sand or newspapers, then placed in a cool, moist place with the temperature just above freezing point. An unheated room in the cellar is suitable. Onions, squash, and pumpkins keep best in a dry room at a temperature halfway between the freezing point and that of a comfortable room.

STORING FRUITS FOR WINTER. Some orchard fruits, especially apples and pears, may be kept tasty and healthful for several months if properly packed and stored. The quality of fruits gradually decreases due to three causes: loss of moisture by evaporation, resulting in shrivelling; decay, due to a disease called rot; and loss of flavour through time.

Apples should be harvested when mature but still firm. Pears should be picked while still hard, but with a yellow tint showing, then left to ripen in a cool, dark cellar, preferably wrapped in paper.

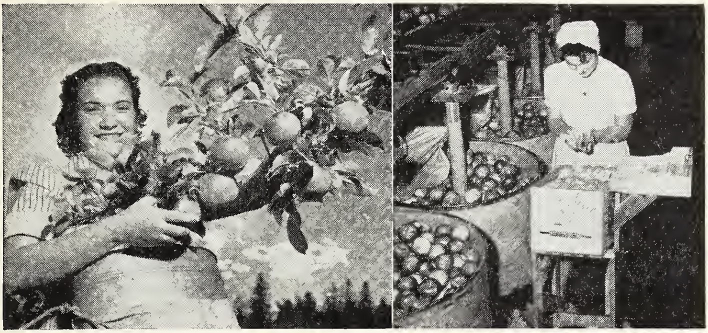


FIG. 1-2. HARVESTING CANADA'S APPLE CROP.

Left: picking McIntosh Red apples in the Okanagan Valley, B.C.; right: sorting, wrapping, and packing apples.

The fruit should be sorted so that no specimens that are under-sized, diseased, wormy, poorly coloured, bruised, or marked will be packed. Bruising of the selected fruit must be avoided since decay usually begins in injured places.

A cold-storage plant provides the best keeping conditions. A cellar with a temperature just above freezing point and well ventilated is quite satisfactory. The low temperature prevents rapid evaporation and shrivelling; ventilation helps to prevent decay.

Plants Give Us Shelter and Clothing

Throughout the ages man has depended upon plants for both shelter and clothing. The primitive tree-houses, the Indian wigwams and tepees, and the pioneer log houses were built almost entirely of logs, poles, and grasses, perhaps supplemented with hides from plant-eating animals. A little investigation and thinking will show us that our modern homes use plant materials in many parts of their construction. Once built, most of our homes are heated by wood, coal, or coke, all of which are also derived from plants.

Cotton, linen, rayon, and rubber are used in much of our clothing today. Cotton fibres come from the fine hairy tufts on the seeds of the cotton plant; linen is made from the long, silky fibres in the stems of flax plants; rayon threads are manufactured from pulpwood; and rubber is derived from the sap of the rubber tree. Nylon, first made in Canada in 1942, is a product of coal, and therefore may be traced back to the prehistoric trees from which the coal was derived. Even the silk, fur, wool, and leather that we wear have been made possible by plants, for green plants nourish both the silkworms and the other animals from which we obtain these materials.

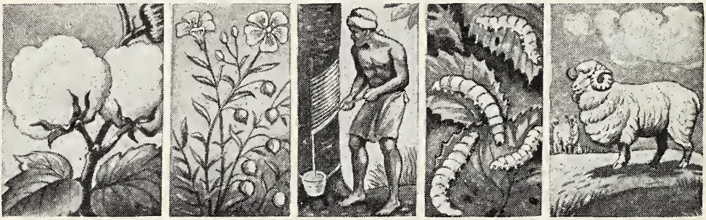


Fig. 1-3. Plants Give Us Our Clothing.

Cotton, from hairs attached to the seeds of the cotton plant; linen, from the fibres of flax stems; rubber, from latex, the milky sap of the rubber tree; silk, from the cocoons of silkworms that feed on mulberry leaves; wool, from sheep.

The manufacture and the use of these plant materials have been important for ages past. Egyptian mummies were wrapped in linen. When Pharoah welcomed Joseph, he "arrayed him in fine linen". Cotton was grown centuries before the time of Christ, and has long been the main fibre used in much of our clothing. The use of rayon, a product of the modern industrial age, has increased enormously in the last half century. Not only have plants provided us with much of our clothing; they have made possible the industries which give a living to millions of people.

Plants Beautify the Earth

Beautiful things appeal to nearly everyone. Nature has used trees, shrubs, flowering plants, even green grass, to make beautiful scenes for us to enjoy. Some of these are in our gardens; others are along the roadside; still others are in woods or along streams.

GARDEN PLANTS. Beautiful gardens are at hand for most of us to enjoy. They may be at home, in a neighbour's yard, or at school. The lawn and the surrounding garden may be thought of as an outdoor living room. The soft, green grass is like a soft rug; the trees and shrubs around the edges represent the drapes; and the beds of flowering plants take the place of beautiful ornaments and furniture (fig. 4-1). We will all get more pleasure from these if we try to learn the names of some of the plants, discover how they live, enjoy their pleasant perfumes and bright colours — and work among them.

Each flowering plant in the garden has its place. Some, like sweet alyssum and blue ageratum, are low enough for borders;

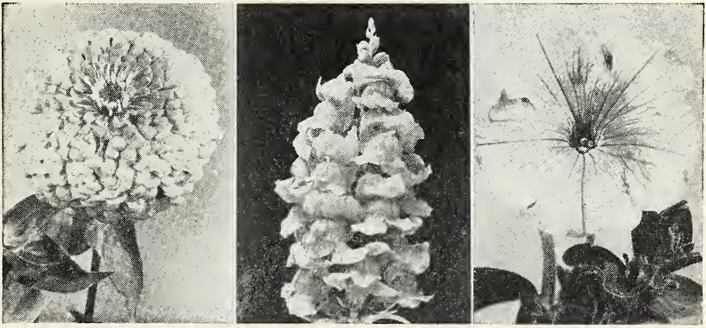


FIG. 1-4. ANNUAL FLOWERING PLANTS FOR THE GARDEN.
Left, zinnia; centre, snapdragon; right, petunia.

others, like scarlet salvia and African marigold, are tall enough to form interesting backgrounds; still others, of medium height, such as phlox, verbena, and snapdragon, give us a variety of colours.

Some Investigations

1. Find as many flowering plants as you can at home, at a neighbour's, at school, or in a park. Ask someone who knows flowers well to go with you and name them for you. Take time to enjoy their beauty, to smell their perfumes, and to watch bees flitting about from flower to flower.

2. Copy the following table and fill it in as far as you can:

Garden Flowers I Found

Name	Colour	Height	Use	What I Liked about them
Petunia	various	1 foot	bedding	Velvety feeling

3. Make a list of several flowers that (a) have sweet perfume, (b) close at night, (c) grow well in hot, dry places, (d) smell sweetest at night, (e) bloom well in shade.

4. Find out by practice the best ways to distinguish garden plants. Select two kinds such as petunia and snapdragon. Compare their flowers in colour, arrangement, size, and perfume. Find how the leaves differ in size, shades of green colour, and arrangement. Tell others why you like one plant better than the other.

WILD FLOWERS AND FERNS. Nature has planted gardens of her own on the roadside, in fields, and in woods. These are particularly attractive in late summer and autumn when their flowers are most plentiful and their colours gayest.

To learn to know and to enjoy wild flowers best we must visit them where they grow. A class hike gives both teacher and pupils an opportunity to investigate and enjoy them together.

Wild asters and goldenrods are easily found in almost any locality. The asters have large clusters of small blue or white flowers; the goldenrods have tall plumes made up of many tiny golden flowers. And what a beautiful showing they make when found together!

Many other wild flowers add colour to the autumn landscape. Joe-Pye weed, named after an Indian Chief, is a tall, slender swamp plant, recognized by its flat-topped clusters of tiny, but showy, rose-purple flowers. Jewel weed, also called spotted touch-me-not, common in wet woodlands, bears orange-yellow, bell-like flowers, followed by pale green pods which split open and throw their seeds when merely touched.

Places which are too shady for most flowering plants may have dense growths of ferns. Nature usually provides an attractive picture by having ferns of different heights, a wide variety of lacy leaves, and many shades of green grow close together. See fig. 1-5.

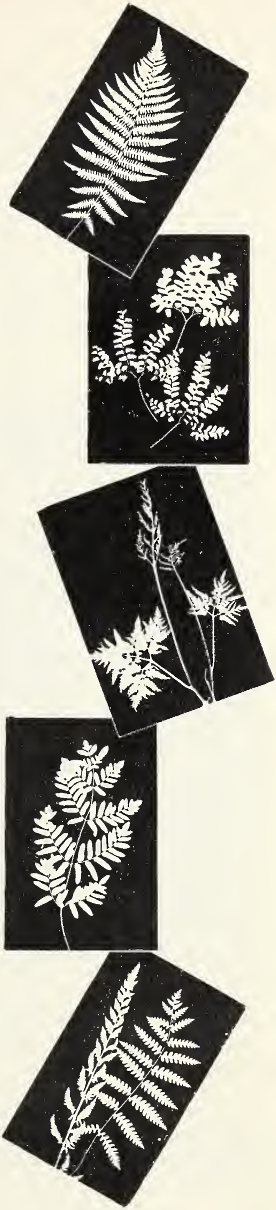


FIG. 1-5. SOME CANADIAN FERNS.

Five common kinds: New York fern, maidenhair fern, rattlesnake fern, royal fern, and cinnamon fern. Look for these.

PUPIL INVESTIGATIONS.

1. Make a class table to describe wild flowers found in autumn. Include such facts as height, odour, and other characteristics of flowers and leaves. Mount coloured pictures of each variety. Try to include some of these: boneset, daisies, Joe-Pye weed, thistles, wild sunflower, wild asters, and goldenrod.

2. Bring specimens of wild flowers to class, place them in jars of water, and label them. Become familiar with them by arranging them in attractive bouquets, sketching some, and playing testing games.

3. Collect leaves of several kinds of ferns. Press them carefully between layers of newspaper and leave them weighted down by books for about two weeks. Consult books to name them, then label them. Your teacher may show you how to make blueprints instead.

TREES AND SHRUBS. Trees and shrubs add beauty to our surroundings. They may grow naturally in wood and field, or they may be planted in parks, streets, and home surroundings. We enjoy them most when we can call them by name. It is easy to become familiar with them by visiting them often, enjoying their shade, and at the same time learning to recognize them by their shapes, their leaves, and their fruits. Autumn is a good time for these activities, for then the trees form their fruits, display their bright colours, and finally get ready for winter.

Learning Activities

1. Examine a maple tree (or other kind) from a distance. Make a pencil sketch of its shape. Go closer to it, then add more details to your sketch. Make similar sketches of other kinds of trees. Label each.

2. Collect typical leaves from each of several kinds of trees. Press, mount, and label them as you did the ferns. Use fig. 1-6 to identify them.

3. Copy the following table in your notebook. Complete it by listing several kinds of trees and giving their identification features. Consult any good book on trees for help.

How To Know the Trees

Name	Shape	Leaves	Fruits	Other Characteristics
White Pine	irregular, with sloping branches	needles in clusters of five	cones with thick scales	
Sugar Maple	(draw this)	five-lobed, notches rounded,	with two wings	varied autumn colours

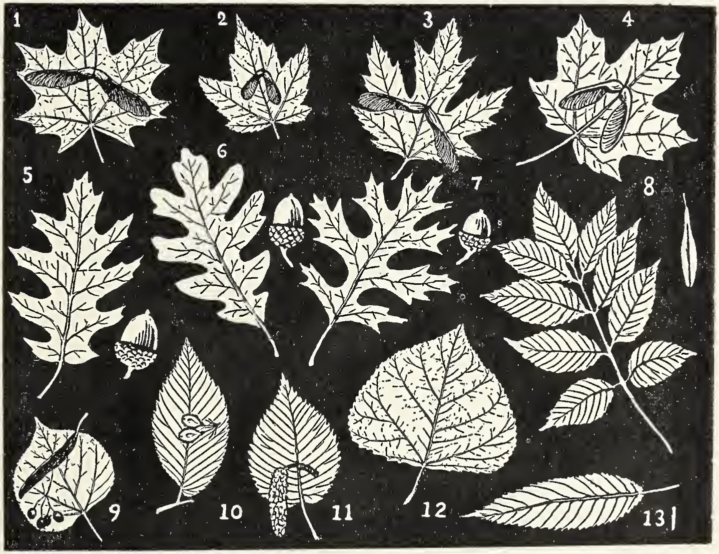


FIG. 1-6. LEAVES AND FRUITS OF COMMON TREES

1, Norway maple; 2, red maple; 3, silver maple; 4, sugar or hard maple; 5, red oak; 6, white oak; 7, black oak; 8, white ash; 9, basswood; 10, American elm; 11, white birch; 12, Carolina poplar; 13, willow.

Plants Meet Special Needs

Man has always used plants to satisfy a wide variety of special needs. Modern ways of living, and the continuous march of science, are constantly increasing the ways in which plants serve man.

Let's look around first in the classroom. The paper in daily use was made from the fibres or pulp of trees, from wastes of cotton and linen, even from straw. Perhaps galls on oak leaves helped in making the ink. Then there is the wood in our pencils, desks, and other equipment.

In our homes we find even wider evidence of the special uses of plants. The canvas back of linoleum is probably of jute or hemp, while the wearing surface contains much cork from the cork-oak tree, and linseed oil from flax. The colours in the drapes are made possible by logwood, indigo plants, and coal-tar. Leather is tanned by the use of tannin from hemlock, oak, or sumac trees. Evergreen trees give the turpentine, and flax the linseed oil, used in paints. Some perfumes and flavouring materials are products of coal-tar. The spices used in the kitchen and most substances used in medicines come from plants.

Nature has given her richest gifts to man in the form of plants, and no one can foretell what new plant gifts from nature still lie hidden.

Some Unusual Plants

When the surface of the earth was all rock, before rain and frost and running water had formed any soil, *lichens* managed to live. The grey, flat bodies of these plants may still be found clinging to the surface of rock. Here they dissolve some of the rock for nourishment, and produce a little soil when they die. On stones, usually moist ones, grow cushions of *moss*. Without leaves, stems, or flowers, but having green colour, they grow

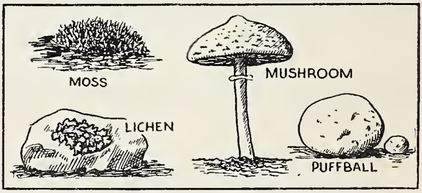


Fig. 1-7. Some Plants That Do Not Have Seeds.

and help to form soil. These lowly lichens and mosses thus help to produce soil for the larger plants which follow them.

Other plants, too tiny or inconspicuous to attract attention, help in special ways. Yeast plants have long been useful in the making of bread. Some special kinds of moulds add flavour to cheese. Various kinds of bacteria help in the making of cheese and butter, others in the decay of plant remains to enrich soil.

Some Plants Are Harmful to Man

DANGEROUS PLANTS. While enjoying plants that add to our pleasure, we must always be on the alert for others that are harmful. Poison ivy is one of the most common injurious plants, and one to be avoided with greatest care. It usually creeps low along the ground, but sometimes climbs on supports. The illustration shows you how to know it. Do not touch it or let it come into contact with clothing which may later touch the skin. Other plants to be avoided are: stinging nettle, which causes intense itching or irritation of the skin; water parsnip, poisonous to the skin, especially when wet; poison hemlock and poison sumac. The berries of red baneberry and white baneberry are poisonous if eaten. You should find out how to recognize each of these harmful plants. Of

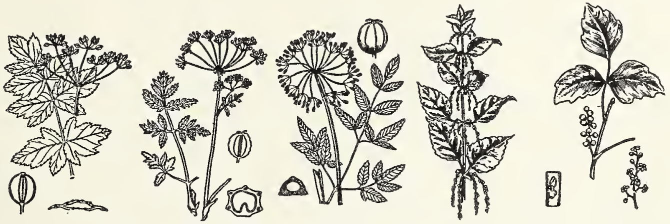


Fig. 1-8. Some Plants To Be Avoided.

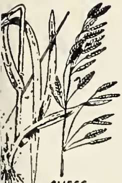
course, one should never collect mushrooms for food unless he is sure that they are edible.

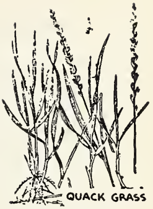
WEEDS. How Weeds Do Harm. Plants which we do not want in our lawns, gardens, and fields are called weeds. They rob nearby plants of space, moisture, and food. When they are tall, they also shade their neighbours enough to keep them from growing well. In these ways they reduce the growth of other plants, making the crops less valuable.

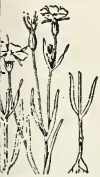
Weeds also cause losses to farmers and market gardeners in other ways. They shelter insects and diseases which attack useful plants. Some weeds are poisonous to man and grazing animals. Weed seeds in grain make it unfit for sowing. Extra labour is required to destroy weeds. You can easily see, therefore, that a weedy farm is less valuable to the owner and would bring a lower price if sold.

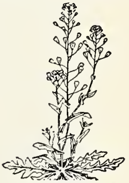
How Weeds Are Spread. Weeds are usually spread by seeds. Those formed by thistles and milkweeds bear tufts of hairs which carry them in the wind. Plants of tumbling weeds and old witch grass are rolled along the ground by the wind and drop their seeds as they go. Seeds of dock and ragweed are light enough to float in water from farm to farm. The barbs on the seeds of burdock, hound's tongue, and pitchfork bur enable them to be carried by dogs, sheep, and other animals. Many weed seeds can pass unharmed through the digestive systems of farm stock and be spread in manure. Farm machinery and seed grain often carry weed seeds to new farms.

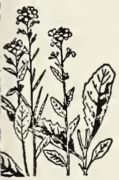
Such weeds as Canada thistle, perennial sow thistle, quack-grass, and field bindweed are spread chiefly by underground stems. These grow out in several directions. Each joint of these weeds can produce a green plant above ground. Farm machinery often cuts such underground stems into smaller pieces and scatters them to other parts of the field. New plants then grow from each joint.

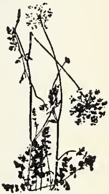


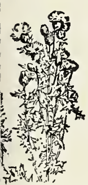


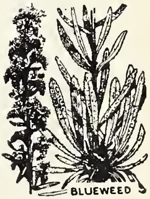


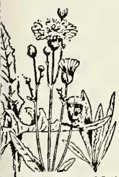












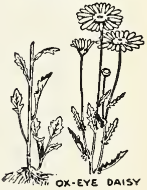


FIG. 1-9. WEEDS I SHOULD KNOW.

Note 1. Abbreviations below: A.—annual; B.—biennial; P.—perennial; W.A.—winter annual; W.P.—in waste places; R.S.—on road-sides; C.F.—in cultivated fields; M.—in meadows, hay, or pastures; G.—in gardens; Fl.—flower; U.S.—spreads by underground stems; H.C.—control by hoed crops; C.R.—control by crop rotation; F.P.—control by fall ploughing; S.F.—control by summer fallowing.

Note 2. (a) where found and how known; (b) how spread; (c) general remarks and control.

Note 3. The table below is meant to be used only for weeds actually found by pupils.

I. COMMON IN GRAIN CROPS

Chess (Cheat): (a) in winter wheat and rye; (b) in seed grain and stock feed; (c) A. or W.A.; C.R.; H.C.; avoid winter wheat.
Purple Cockle: (a) Fl. purple; stems hairy; (b) in seed wheat; (c) darkens and flavours flour; S.F.; pull.
Wild Mustard: (a) in any crops and W.P.; Fl. yellow; (b) in seed grain and clover; on machinery; (c) serious pest; pull; S.F.; F.P.
Canada Thistle: (a) Fl. purple or pink; (b) wind-blown seeds; U.S.; (c) P.; serious menace; S.F.; H.C.
Perennial Sow Thistle: (a) Fl. yellow; W.P.; C.F.; (b) wind-blown seeds; U.S.; (c) P.; pest; S.F.; H.C.; C.R.; sheep.
Field Bindweed: (a) Fl. white, pink; (b) branching; U.S.; (c) F.; persistent cultivation; smother by means of straw; chemicals.

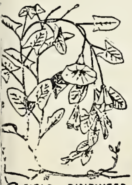
II. COMMON IN MEADOWS AND PASTURES

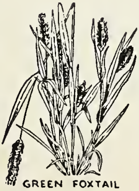
Quack (couch, twitch) Grass: (a) anywhere; (b) U.S.; (c) P.; cultivate, rake, burn; S.F.; H.C.; C.R.
Shepherd's Purse: (b) seeds numerous, in seed grain and clover; (c) A. and W.A.; S.F.; H.C.
Wild Carrot; (a) R.S.; W.P.; M.; Fl. white; (b) in clover seed; (c) B.; C.R.; cultivation; sheep pasture.
Blueweed: (a) R.S.; W.P.; hairy; Fl. blue; (b) seeds; (c) B.; cut closely; C.R.; F.P.
Ox-eye Daisy: (a) old M.; Fl. white with yellow centre; (b) in timothy seed; U.S.; (c) P.; C.R.; shallow ploughing.
Chicory: (a) R.S.; Fl. blue, purple; (b) in clover and grass seed; (c) P.; C.R.

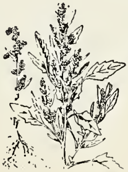
III. COMMON IN HOED CROPS

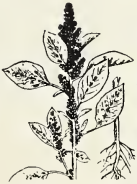
Green Foxtail: (a) too common; (b) in clover seed; (c) A.; cultivate.
Lamb's Quarters: (a) C.F.; pale green; (b) in clover seed; (c) cultivate; S.F.
Red-root Pigweed: (a) H.C.; root pink; (b) seeds long-lived; (c) A; pull; cultivate often.
Purslane: (a) G.; leaves fleshy; (b) seeds long-lived; (c) A.; cultivate often.

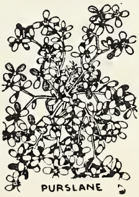
(Canadian Department of Agriculture)

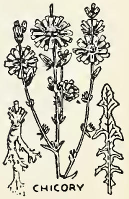












How Weeds May Be Controlled. Preventing weeds from getting a start is easier and cheaper than destroying them later. Good farmers do this in several ways. They sow only pure seed. They see that farm machinery and threshing separators are free from weed seeds before they take them from one farm to another. They are very careful not to buy feed or manure containing weed seeds.

Weeds that do get a start should be prevented from maturing and scattering seeds. Thorough and frequent cultivation of gardens and hoed crops causes resting seeds to germinate and kills weeds as they grow. It also brings the underground stems of weeds to the surface where dryness and sunlight kill them. Fields that are very weedy may have to be kept in cultivation all summer to completely rid them of these pests. Sometimes farmers grow buckwheat or other densely growing crops to smother them. Weeds in grain crops should be pulled by hand before they are ripe. Then the grain stubble should be cultivated immediately after the harvest. Sheep eat the tops of some pasture weeds. Those on roadsides and in fence corners and pastures should be cut before the seeds mature. The most modern method of controlling weeds is to spray their foliage with chemicals specially prepared to kill them.

Through "the Ontario Weed Control Act" the Ontario Department of Agriculture requires that "every occupant of land or, if the land is unoccupied, the owner shall destroy all weeds designated noxious by the regulations as often as is sufficient to prevent the ripening of their seeds." Weed inspectors are appointed to enforce this law.

PUPIL INVESTIGATION. What weeds are killed by cutting them off at ground level?

Cut off a specimen of several kinds of weeds even with the ground. Make a list of those that send up new growth, and of those that die. Try to explain why one kind dies while another produces a new top.

Review Questions

1. How are weed seeds commonly distributed? Mention five ways, and name one or more weeds distributed in each way.
2. What precautions should a farmer take to make certain that his seed grain is free from weed seeds?

Things To Do

1. Make a list of the most harmful weeds found in your community, and explain how each causes loss to the farmer.
2. As a class, visit the roadside or a vacant lot near your school, and identify as many weeds as you can.
3. Collect several kinds of ripe weeds found locally. Remove the seeds from a few plants of each kind, and count or estimate the average number of seeds on each plant.
4. Carefully dig up the underground parts of a large plant of Canada thistle, perennial sow thistle, or quack grass. Remove the soil and make a labelled diagram to show how the plant spreads.
5. Complete the following table for several weeds identified locally.

Name of Weed	How Spread	How Controlled
Wild Mustard	numerous seeds	pull before seeds form

Man Makes Plants Serve Him Better

Ever since man learned to domesticate plants, he has been discovering new ways of using them. Doctor Carver, a noted negro scientist and agriculturist, found many new uses for the humble peanut. Later it was found that the soybean could be used to produce numerous useful things, ranging from breakfast foods and soups to linoleum and paints.

Scientists have copied nature in developing new kinds of plants. Luther Burbank, originator of Burbank potatoes, spent much of his life producing new and better kinds of flowers and fruits. Charles Edward Saunders experimented with wheat

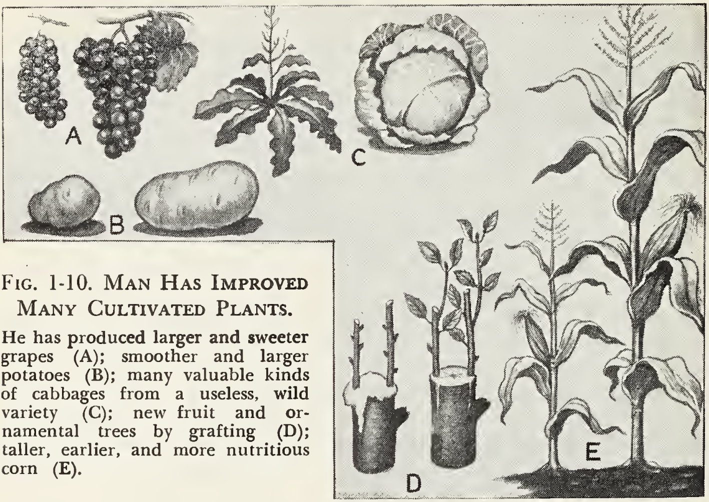


Fig. 1-10. Man Has Improved Many Cultivated Plants.

He has produced larger and sweeter grapes (A); smoother and larger potatoes (B); many valuable kinds of cabbages from a useless, wild variety (C); new fruit and ornamental trees by grafting (D); taller, earlier, and more nutritious corn (E).

until he was able to develop the famous Marquis variety, quick-maturing and, therefore, suited to the conditions of Western Canada. In many Experimental Stations across Canada some of our leading scientists are constantly striving to produce new and better varieties of plants.

To serve special purposes man has introduced many new kinds of plants from other parts of the earth. Alfalfa first grew in Southern Asia. Now it is one of America's most valuable crops. Most of our grains were brought from Europe. Sometimes only an occasional plant of a newly introduced kind grows well. By saving the seeds of these few plants, we are able to obtain a new variety well fitted to grow in the new conditions. See fig. 1-11.

Review Exercises

1. Make a class table to summarize the uses of plants to man. The main heading might read *How People Use Plants,* and the column headings: *Shelter, Clothing, Food, Medicine, Transportation, Furniture, Wrapping Materials,* and *School Supplies.* Include as many plants as you can.

2. In your notebook write the following names of plants in a vertical column: poison ivy, cork oak, pine, flax, cotton, clover, peas, goldenrod.

Now read these characteristics: A. feed for livestock; B. poisonous; C. produces material used in dyes; D. a legume; E. a wild flower; F. a high-quality textile; G. produces a material used in painting; H. gives a substance found in linoleum.

After each name list as many letters as you can (A, B, etc.) to indicate characteristics which apply to that plant.

FIG. 1-11. SCIENCE HELPS US TO GROW BETTER CROPS.

Selecting the best heads of wheat for testing at the Central Experimental Farm, Ottawa.

Testing Exercises

1. Complete the statements given below by filling in the blanks with a word or words selected from these: sugar cane, corn, temperate, sugar beet, cotton, potatoes, lichens, rice, wheat, tropical, oxygen, soil.

(a) Plants help us to breathe by giving off ....

(b) Sugar is produced from .... which grows in .... regions, and from .... in the .... regions.

(c) Four of the most important food plants are ...., ..., ..., and ....

(d) The grey, flat plants found growing on bare rocks, and called ...., help other plants by forming .... for them.

2. Name three men who have helped to develop new kinds of plants or to find new uses for old ones.

3. List five ways in which weeds are spread.

4. State three ways of preventing weeds from getting a start and

four ways of controlling them after they have begun growth. Give an example for each way.

5. Name four plants injurious to man.

For Research

Each pupil select one plant useful to man in some way. Investigate and give your class an oral report of its characteristics, where it grows, and how man uses it.

◆

Read

Compton's Pictured Encyclopedia: "King Cotton and His Gifts to the World", Vol. 3, pp. 491-498, and "What Men Do with Plants", Vol. 11, pp. 298-308.

16 mm. Sound Films

Apples (colour) (SA-17)
Ontario Visual Education Branch

Daily Bread
Associated Screen News Limited, Toronto

Just Weeds (colour)
National Film Board, Ottawa

2

HOW GREEN PLANTS MAKE A LIVING

MOST OF US have heard the expression "the green earth". With the exception of desert and polar regions, a large part of the earth would indeed appear green to us as we looked down on its trees, crops, and grass from a low-flying aeroplane. In this chapter we shall find out how important the green leaves of plants are to man, and how they are helped by the roots and stems.

The Needs of Green Plants

Green plants can serve us as they do because nature has fitted them so well to grow in the conditions which Mother Earth provides. Let us find out first what conditions green plants must have to grow well. Scientists through the ages have gradually learned about these by experiments and observations. We can discover them for ourselves in a few days by performing the following experiments carefully.

Note: The first experiment below should be planned and set up two or more weeks before reading the remainder of this chapter.

EXPERIMENT 2-1. What conditions are needed by green plants to grow well?

Grow a few bean or corn plants, or a small geranium plant, in each of five pots, A, B, C, D, and E. Keep all five in a warm, bright place, and the soil moist, until all plants are growing well. Leave A in the warm, bright room and keep its soil moist. Leave B in the same place, but do not water it. Keep C in a similarly warm place, and moist, but under a box or in a cupboard to exclude light. Place D in a bright but cold porch and water it as you do A and C. Put pot E in a deep vessel containing enough water to always cover the soil, but where it is warm and bright. Observe these for a few days.

In which pot do the plants grow best? What conditions do these plants have? Which of these conditions is lacking with the plants in pot B? Pot C? Pot D? Pot E?

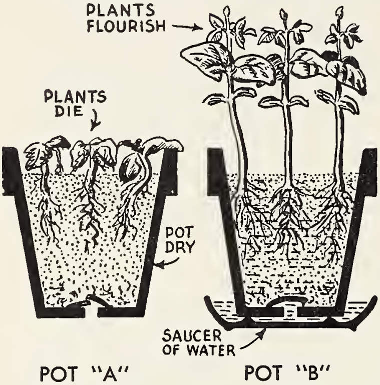


Fig. 2-1. Plants Need Water.

PLANTS NEED WATER. Field crops, garden plants and house plants grow more slowly when the soil becomes dry. In periods of drought the grass in lawns may become brown, and even brittle. If the soil of house plants is not watered, they soon wilt and die. Weeds pulled from the soil and flowers cut from plants and not placed in water also wilt and die. On the other hand, forests grow most luxuriantly in regions of heavy rainfall. How can we explain these happenings?

Water makes up a large part of the weight of most plants. When fallen leaves dry up, they weigh only about one-tenth of their original weight. About nine-tenths of the weight of the roots, stems, leaves, and flowers of plants is water. A lawn of average size will use up several barrels of water each summer day.

Water is useful to plants in many ways. It is a raw material from which they make food. As it enters the plant, it carries with it other raw materials from which the plant makes food. Just as air in a balloon holds it out rigidly, so the water in stems and leaves holds them up in a natural position rather than drooping.

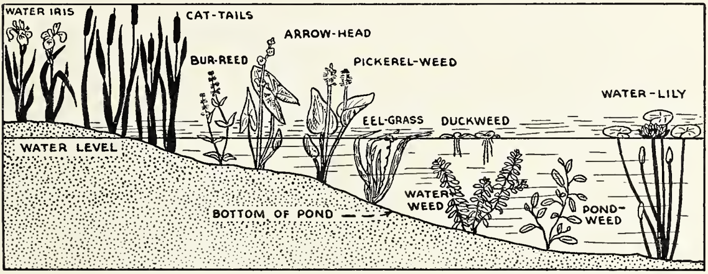


FIG. 2-2. COMMON WATER PLANTS AT HOME.
Some live near the shore; some live in deeper water; others float.

Plants differ greatly in the amount of water needed to grow well. Most ferns grow best in wet places, while cacti thrive with little moisture. Forests need more rainfall than prairie grasses.

PLANTS NEED LIGHT. Most house plants grow sturdiest in a south window. Without such bright light they usually grow spindly. Nearly all plants profit from some direct sunlight. Even ferns, begonias, and African violets, usually grown in north windows, receive sunlight reflected from the sky. Have you noticed how plants grown indoors bend or turn their leaves so they face the light? Even the flowers of sunflower plants turn during the day so they always face the sun. Farm crops and vegetables do not grow well in the shade of trees or buildings.

EXPERIMENT 2-2. How does light affect the growth of plants?

Cover some grass with a board for three or four days. What change in colour takes place? What change in growth? The covered grass received as much moisture and warmth as uncovered grass. What condition needed for growth did the covered grass lack? Plants cannot remain green without light.

Uncover the grass. Examine it each day for three or four days. What change in colour takes place? What change in growth? Why?

When deprived of light, the grass lost its green colour and stopped growing. As soon as the grass received light again, it regained its green colour. When it had both green colour and light, it began to grow again.

Now we will tell why these things happened as they did. Plants cannot grow without food. They cannot make food without green colour. They cannot make green colour without light. Therefore, when plants obtain enough light, they make green colour; when they have both green colour and light, they make food. Then they grow.

PLANTS NEED WARMTH. Few plants can remain active below freezing point; many die as soon as frost touches them. Nearly all plants grow fastest when both the air above ground and the soil around their roots is warm. Our experiment 2-1 showed us this fact. Many seeds will not germinate unless the temperature is much above freezing point. For this reason farmers do not sow grain or plant corn until the soil has warmed somewhat in spring. Plants differ widely in the amount of heat they need. For example, tropical plants do not grow well in temperate regions.

PLANTS NEED AIR. In experiment 2-1 we saw that the plants in pot E soon stopped growing and died. This happened because their roots, always surrounded by water, could not get enough air. Crops in water-covered fields, and trees in swamps, frequently die, too, for lack of air. Most plants grow best in soil loose enough to admit air to their roots. Indoor plants grow best in homes and greenhouses that are well ventilated. Seeds fail to germinate when water covers them and keeps out air.

Green leaves must have air. If a green leaf is cut in two and held under hot water, bubbles of air escape from it. To show that leaves need this air, smear vaseline over both sides of some of the leaves of a house plant and not over the others, then observe the effect after a few days. Leaves must take in carbon dioxide from air as food. Like all living things, they must also have oxygen to breathe.

PLANTS NEED MINERALS. Some soils produce much better crops than others even when given equal amounts of water. They differ in the kinds and amounts of minerals they can give the plants.

EXPERIMENT 2-3. How do minerals affect plant growth?

For this experiment use plants from pot A of experiment 2-1. Plant equal-sized plants in each of these three conditions: A, in pure sand kept watered with rain water; B, in pure sand kept watered with rain water containing some fertilizer; C, in good garden soil. Keep all three in a warm and light place for three or four weeks. Compare the growth and health of the plants.

Sand contains little mineral matter that plants can use. Rain water does not contain minerals. Fertilizers provide the minerals the plants need. Good soil already contains these ready for plants to use.

Plants receive these five essentials — water, light, warmth, air, and minerals — when grown in good soil and exposed to fresh air and warm sunlight. The soil, if properly cared for, provides minerals, moisture, and air for roots. Fesh air gives the oxygen for breathing, and the carbon dioxide for food-making. The sun gives the light needed by the plant to produce green colour and make food for growth. It also warms the soil and the air.

The Essential Parts of Green Plants

Just as our bodies have special organs with which to move about, breathe, eat and digest food, so plants have different parts, each with its own special functions to perform. The usual parts of green plants are roots, stems, leaves, flowers, fruits, and seeds. The roots hold the plant in place and gather raw food for it. The leaves prepare the plant's food for use in growth. The stems hold the leaves up to sunlight and carry raw food from roots to leaves, and manufactured plant foods from the leaves to all other parts of the plant. The flowers, fruits, and seeds help to produce new plants. These different parts are adapted to work together in the best interests of the whole plant. Nature often gives these different parts special adaptations to meet special conditions of shade, dryness, and wind.

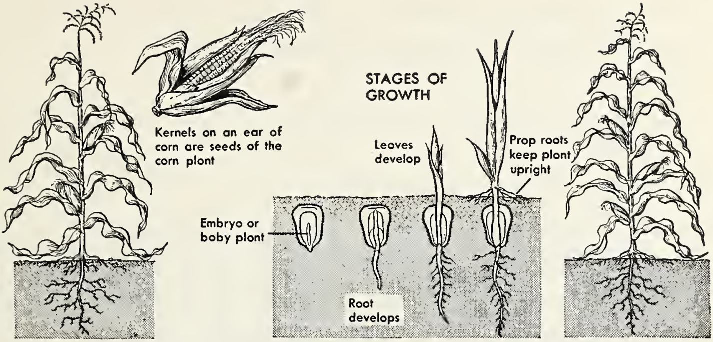
THE CORN PLANT. Let us find out how the different parts of a corn plant adapt it to live. Notice the erect nature of the plant, and how well its leaves are exposed to the sunlight and air which they need. Bend the plant and let it go. How does its strength and flexibility fit it to withstand strong winds? Look for little roots propping the sides of the plant.

The Root System. Pull up the plant. Why was it so hard to pull? Notice the large amount of soil adhering to the mass of roots. How far away was the ground disturbed?

Shake off the soil. Examine the large number, the strength, and the branches of the roots. It has been estimated that the total length of the roots and branches of a corn plant may total two miles. Think of the support such a mass of roots gives to the plant, also the large amount of soil from which it can gather food.

A root system like this, with so many roots in the cluster, is called a *fibrous root system*. How does it compare with a river system having many tributaries?

The Leaves. See how the leaves are attached to the stem. Tear one lengthwise. Notice its long veins. These strengthen the leaf and carry water and foods. Leaves which have veins lying side by side like these are described as having *parallel veins*. Little damage is done to such veins when the leaves


Kernels on an ear of corn are seeds of the corn plant
STAGES OF GROWTH
Leaves develop
Prop roots keep plant upright
Embryo or baby plant
Root develops

(From the WORLD BOOK ENCYCLOPEDIA, copyrighted by Field Enterprises, Inc. Reproduced by special permission.)

FIG. 2-3. HOW A CORN PLANT LIVES.

On this drawing find: the prop roots, parallel veins in the leaves, and the silk on the ear, well adapted to catch pollen drifting from the tassels.

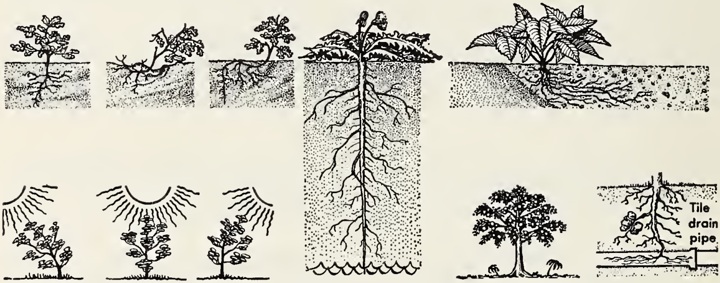
become torn lengthwise. Characteristics like these which work for the good of the plant are called *adaptations.*

The Stem. We noticed the strength and flexibility of the stem. What gives it these? Cut a stem part way across, then tear it lengthwise. Examine the hard, strong outer cover. Pick out some of the long, thread-like fibres which extend lengthwise in the soft interior. These are little tubes which carry moisture and raw food up to the leaves, and manufactured food down.

Flowers and Fruits. How does the corn plant prepare for new plants? Notice how the ears, containing seeds, are attached at strong joints. Examine the tassel at the top. This produces the yellow pollen necessary for the plant to produce seeds. The tassel is well adapted by being held high in the air, giving the wind a better chance to carry the pollen to the parts of the plant that produce the ears.

THE DANDELION PLANT. A dandelion plant is well fitted to grow in lawns and among tall plants.

The Leaves. Examine the leaves of a large, healthy dandelion plant in a field or lawn. Notice how they are arranged around the plant, facing upwards to the best light even when grass grows high around the plant. Notice that neither the lawn mower nor the feet of people harm them. See how the veins of a leaf form a network. Tear a leaf. Compare their veins with those of the corn plant. Leaves with veins like these are said to be *net-veined.*



(From the WORLD BOOK ENCYCLOPEDIA, copyrighted by Field Enterprises, Inc. Reproduced by special permission.)

FIG. 2-4. WHAT PLANTS DO TO SURVIVE.

In this drawing find: the deep, strong tap root of the dandelion plant in the middle; roots overcoming difficulties to penetrate the soil; roots turning toward loose, airy soil and a moist drain pipe; stems turning toward sunlight.

The Roots. Carefully dig up the whole root system of a dandelion plant. See how the long, strong central root reaches deeply into the soil. By so doing it can gather moisture and food from deep down. By extending sideways and downwards the branches of the main root can gather food from wider areas. Roots like this are called *tap roots.*

Flowers and Fruits. The dandelion flower is really a cluster of many small flowers. Remove some of these. The bees seen going from flower to flower carry pollen and help the flowers to produce seed. Find a tall, filmy cluster of seeds. Notice how well the hairy balloon on a seed is fitted to carry it in even a light breeze.

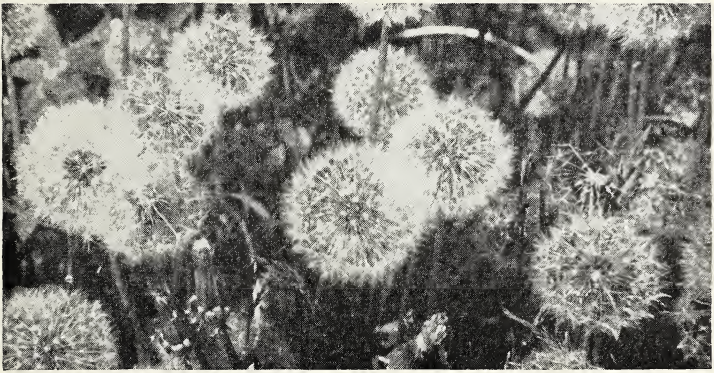


FIG. 2-5. DANDELION HEADS.

The Work of Roots

ROOTS ANCHOR PLANTS. Our study of the corn plant and of the dandelion plant showed us how the roots of each are well fitted to anchor the plant in the soil and to hold its stem or leaves up to favourable conditions of light and air. The roots of most plants serve the same purposes.

ROOTS ABSORB FOOD. A plant pulled from the soil soon wilts and dies. Why? Its roots can no longer take in water and other plant foods from the soil. The larger a root system is, the greater the volume of soil from which it can gather food for the plant. A series of experiments will help us to understand how roots take in water and other foods.

EXPERIMENT 2-3. Do roots take in water?

Wax a piece of cardboard by dipping it in melted paraffin. Cut it to fit the top of a bottle or sealer. Make a hole in its centre the size of a pencil, and make a slit from the hole to one side. Fill the bottle with water. Carefully dig up a small plant and shake the soil from its roots. Fit the plant into the card, and the card into the bottle, so that the roots hang down in the water. Seal around the plant stem and the edges of the card with vaseline. Fig. 2-6 shows another method of performing this experiment, using a cork in place of the cardboard.

Keep the plant in the classroom for a few days. What change takes place in the level of the water? Where did the water go?

This experiment helps us to understand why trees in a lawn make the soil dry out.

Water in soil contains some dissolved mineral substances. This can be shown by shaking a mixture of garden soil and rain water, letting the soil settle, pouring off some of the clear water, and evaporating some of this water in a clean dish. Some mineral substances, useful to plants, would be left in the dish. They must have been dissolved from the soil by the water. Both the water and the minerals in soil are foods for plants.

EXPERIMENT 2-4. What parts of roots are specially adapted to take in water and dissolved minerals from soil?

Make a pad of blotting paper several layers thick. Place this in a saucer. On it place several seeds of wheat or radish. Invert a tumbler over them. Pour water into the saucer until all of the blotting paper is wet, but the seeds not covered. Leave this in a warm place for three or four days.

Notice the little fuzzy hairs on the roots. These are called *root hairs.* Remove the tumbler and leave the root hairs exposed to air. What happens to them?

Root hairs grow on all the small branches of the roots of plants. Thus they reach into a large volume of soil. From it they absorb the water and the dissolved minerals that the plants need.

Root hairs are very delicate organs. They shrivel up when exposed to air, and are easily broken off when a plant is pulled or dug up. New root hairs soon grow again when the roots are put back into soil.

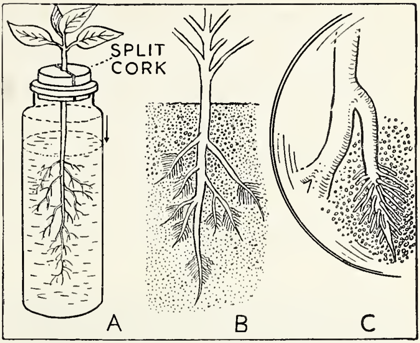


FIG. 2-6. HOW ROOTS WORK FOR PLANTS.

A. Roots take in water. B. Numerous root hairs grow near the end of all root branches. C. Root hairs are like delicate little tubes, taking water from the soil into the roots.

EXPERIMENT 2-5. How are root hairs fitted to absorb moisture?

(a) Place dried prunes, slices of slightly shrivelled beet, and wilted celery in fresh water. What change takes place in these? Did water seem to enter or to leave them?

(b) Hollow out a potato or a parsnip. Place it in a tumbler. Fill the vegetable with syrup. Put water in the tumbler to the level of the syrup. Leave the experiment over night.

What made the level of the liquid inside the potato or parsnip higher than that outside? How did the extra water get in?

Every root and root hair contains sap, something like the syrup used here. Outside it there is soil water, a thinner liquid. The soil water therefore passes through the outer covering into the root. The delicate, thin walls of root hairs take in soil water easily. The process is called *osmosis*.

EXPERIMENT 2-6. Through what part of a root is soil water carried upwards?

Cut about an inch from the lower end of each of two carrots or parsnips. Place the roots in a tumbler one-quarter filled with water coloured with red ink. Leave them two days. Cut slices crosswise and lengthwise of the roots. Find the red stains showing where the ink went up.

THÉRIEN S.D. 2149
THÉRIEN, ALBERTA

Roots contain tubes, something like the fibres in corn, which carry water and dissolved minerals upwards.

ROOTS STORE FOOD AND PRODUCE NEW PLANTS. In addition to holding the plant in place and absorbing food, most roots store manufactured food for later use by the plant. Many roots have buds which later produce new growth. We shall learn about these in the next chapter.

The Work of Leaves

We think of modern factories as very important because they make so many kinds of things we need. Nature has factories even more important to us, for they make possible all our food. These factories are green leaves.

LEAVES PREPARE FOOD FOR PLANTS. A factory, to be profitable, must have a building, machinery, power, and raw materials. It must make useful products. There must be a means of transporting raw materials to it and of taking away both the useful products and any waste substances. Every green leaf of a plant is such a factory.

The green colour in leaves, called *leaf-green* or *chlorophyll*, serves as the machinery for the making of plant foods. This machinery works only in light, for sunlight is the power that operates the leaf factory. Leaves receive water and minerals from the soil and carbon dioxide from the air as raw materials. These they make into starch and sugar and other digestible plant foods.

The experiments suggested below will show us how leaves are fitted for this work.

EXPERIMENT 2-7. How are water and dissolved mineral substances carried from the roots to the leaves?

Cut a short branch from a house plant and place the cut end in red ink, leaving it for a day. Examine the leaves each half hour or so.

How soon did you see red ink in them? How did it get up to the leaves? Cut through the stem part way up to see the red ends of the little tubes that carry up water and minerals. Make a drawing to show the position and arrangement of these tubes in the stem.

EXPERIMENT 2-8. How efficiently was the red ink distributed throughout the leaves?

Examine one of the reddened leaves to see how the red ink was distributed to all parts of it. Notice how smaller veins branch out from the main ones to every part of the leaf. Water and minerals from the roots are distributed in these to all parts of the leaf.

EXPERIMENT 2-9. How is the sunlight able to reach all parts of the leaf?

Remove a leaf from any plant and hold it between your eye and the sun. Can you see light through it? The thinness of leaves makes it possible for sunlight to reach every part of them.

Other experiments would prove to us the following facts:

(1) A living green leaf contains starch after the sun has been shining on it for a few hours.

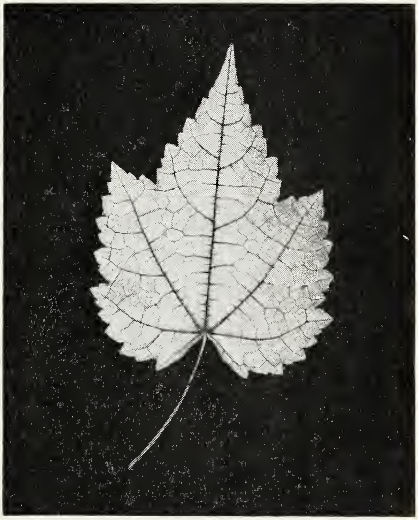


FIG. 2-7. VEINS DISTRIBUTE FOOD.

Compare the branching network of veins in the leaf of the flowering maple with the ink tracks seen in your leaf.

(2) Starch disappears from leaves after the sun stops shining on them.

(3) Only green leaves can make starch.

(4) Green leaves cannot make starch without light.

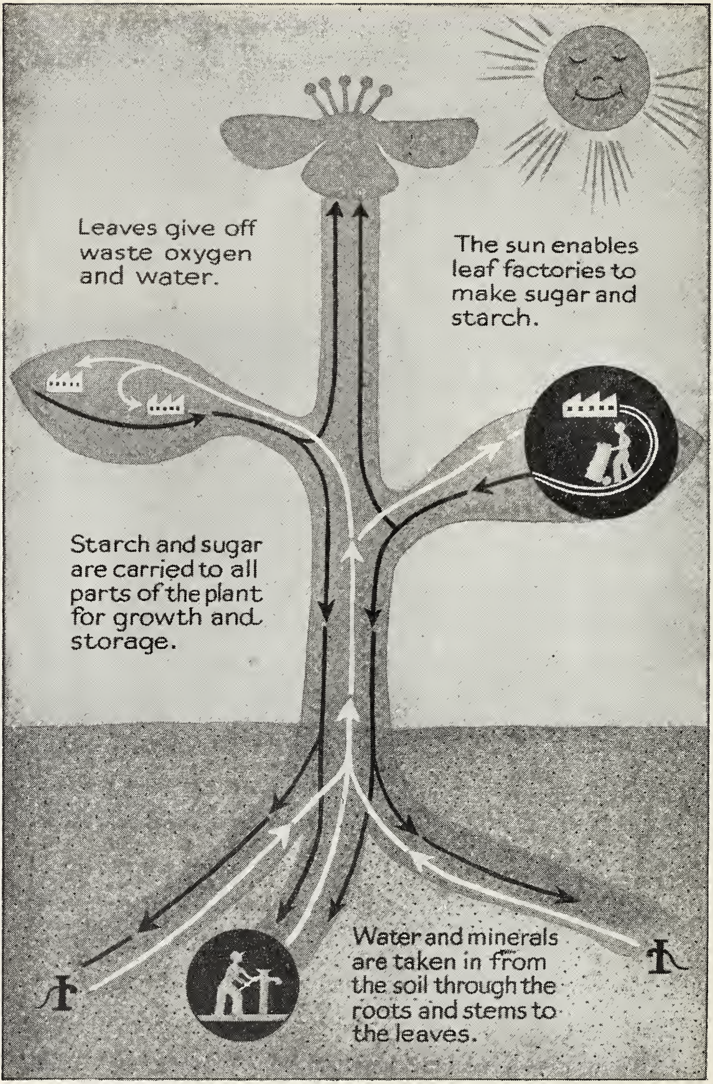

Leaves give off waste oxygen and water.
The sun enables leaf factories to make sugar and starch.
Starch and sugar are carried to all parts of the plant for growth and storage.
Water and minerals are taken in from the soil through the roots and stems to the leaves.

FIG. 2-8. HOW A GREEN PLANT LIVES AND GROWS.

Now let us summarize how green leaves make plant food. The water and minerals brought up through the tubes in the stems are distributed by the veins to all parts of the leaf. Carbon dioxide is also needed. It is taken in from the air through tiny pores in the skin of the leaf. Sunlight shining through to all parts of the leaf makes all the leaf-green (machinery) work, combining the water, carbon dioxide, and minerals to form starch, sugar, and other plant foods. The manufactured food is then transported through the veins and stems to every part of the plant and either stored or used for growth.

LEAVES GIVE OFF WASTE SUBSTANCES. Most factories have some waste materials to dispose of. A lumber mill has sawdust; a cheese factory, whey. When leaves make starch, they likewise have waste materials to dispose of.

EXPERIMENT 2-10. To find one waste material given off by leaves.

Invert a clean, dry, large-mouthed bottle, such as a vaseline bottle, over a few leaves of a healthy plant. Pack cotton batting around the stem at the mouth of the bottle. Support the bottle in this position in sunlight for half a day. Where did the mist and the drops of water in the bottle come from?

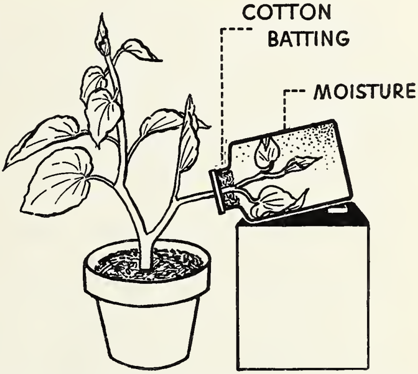


Fig. 2-9. Healthy Green Leaves Give Off Water.

Water is one waste substance given off by leaves. This water has served the useful purpose of carrying mineral substances from the soil to the leaves. It is no longer needed.

A plant soon wilts if its roots do not receive enough water. This is more likely to happen on hot, sunny days, especially if the wind is blowing. Under these conditions, the leaves may give off water faster than the roots can take it in. Then the branches and leaves droop.

Oxygen is another waste substance given off by leaves. The carbon dioxide and water taken in as raw food contain more oxygen than a plant needs to make sugar and starch. The leaves give off this extra oxygen. We can see this happening when we observe bubbles coming from water plants in an aquarium. Much of the oxygen that we breathe was given to the air by trees, shrubs, and crops.

The Work of Stems

Stems are important to plants chiefly because they help leaves and flowers to do their work more efficiently.

STEMS HELP LEAVES TO OBTAIN GOOD LIGHT. We have all observed that the leaves of a house plant in a window usually face upwards and outwards towards the sky. If we turn the plant around, the leaves soon change directions and again face the sky. Their stems bring about this change.

Only by the help of the trunk, branches, and twigs could the thousands of leaves on a tree be exposed to the light they need to make food. By examining a branch of a maple tree we discover that the smallest twigs hold the individual leaves in such positions that they shade each other very little. The stems of corn and grains, and of most wild flowers and weeds, serve the same purposes. All of these stems, standing upright without the help of any support, are called *erect stems.*

The *trailing stems* of pumpkin and cucumber plants hold the leaves above them well exposed to light.

Climbing stems expose their leaves to light with the help of other supports, some by *twining* around objects (morning glory), others by grasping nearby objects by means of coiled *tendrils* (grapes), still others by clinging with the help of little *air roots* (ivy). The *underground stems* of ferns and quack grass send up leaves from each joint.

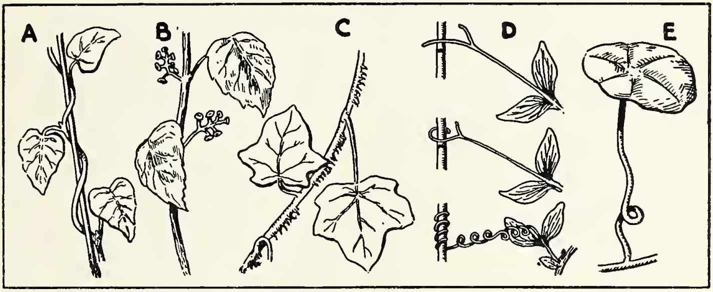


Fig. 2-10. How Plants Climb to Good Light.
A, stem of morning glory twining around a support; B, Virginia creeper clinging by suckers; C, ivy climbing by aerial roots; D, pea tendrils reaching, grasping, and lifting the plant; E, twining leaf stalk of nasturtium.

STEMS CONDUCT WATER AND PLANT FOODS. Experiment 2-7 showed how stems conduct liquids to the leaves. The little conducting tubes or fibres in stalks of corn and celery are easily seen. By means of such tubes all stems are able to carry water and dissolved minerals from the roots to the leaves. Similar tubes in stems transport manufactured foods from the leaves to all parts of the plant where they are stored or used for growth. The leaves of carrots, rhubarb, and dandelion grow directly from the roots, making stems unnecessary.

STEMS SERVE PLANTS IN OTHER WAYS. Some stems store plant foods for later use by the plant. The trunks and branches of maple and other trees, and the underground stems of ferns and quack grass, serve this purpose. The stems of other plants hold the flowers where bees are more likely to see them, then visit them and carry pollen from flower to flower. Similarly the stems hold the fruits of such plants as milkweed high enough that the wind has a better chance of scattering their seeds. Cuttings of geranium plants and pieces of the underground stems of quack grass may start new plants.

Living Plants Breathe

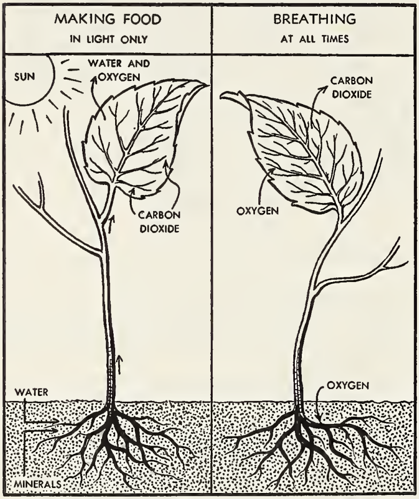


FIG. 2-11. HOW PLANTS MAKE FOOD AND BREATHE TO LIVE.

Plants and animals breathe alike, but feed differently.

All living things, plants as well as animals, must breathe to live. We breathe in oxygen, and use it to help produce body heat and the energy with which we move and work. Plants also live and grow; they, too, require energy. To produce this they must also breathe. Breathing is always the same process, whether by plants or animals; it uses up oxygen and produces carbon dioxide.

Plants feed in a manner quite different from that of animals. Their leaves and roots serve as mouths, the leaves taking in carbon dioxide and the roots absorbing water and dissolved minerals. The leaves, with the help of sunlight, change these raw foods into starch and sugar for plant growth.

Some Things To Remember

1. Only the roots can take from the soil the water and dissolved minerals needed by plants as raw food.

2. The thin walls of root hairs adapt them to absorb soil water.

3. Soil water containing dissolved mineral foods travels up through special channels in the stems and through the stalks of the

leaves. Then it is distributed to all parts of the leaves through the veins.

4. The green colouring matter in leaves is the machinery by means of which they manufacture plant foods.

5. Sunlight penetrates through all parts of the thin, green leaves and becomes the power which operates the machinery.

6. Water and carbon dioxide are combined in the leaves to make starch and sugar. This takes place only in sunlight.

7. These manufactured foods are transported through the veins, leaf stalks, and stems to all parts of the plant. Then they are used for growth or are stored for future use.

8. Green leaves give off water and oxygen left over when the food is manufactured.

Test Questions

1. State the three main functions of roots.

2. In what respects is a root hair in moist soil like a prune in a dish of tap water?

3. What three raw materials are used by leaves for food manufacture?

4. State three ways in which a leaf is fitted to manufacture plant food.

5. List four ways in which stems help leaves to get enough light.

6. What waste products are given off by leaves (a) when they manufacture plant food; (b) when they breathe?

7. State three ways in which stems help leaves do their work.

8. State the important uses of each part of a green plant (a) to the plant itself; (b) to man.

9. Some part of a green plant carries out each of these functions: A. takes in carbon dioxide; B. produces seeds; C. holds leaves up to light; D. makes starch and sugar; E. holds the plant in place; F. absorbs water; G. transports raw foods; H. produces pollen; I. gives off water.

After each of the parts listed below, write as many letters (A, B, etc.) as you can to indicate its particular functions:
root (   ); stem (   ); leaf (   ); flower (   ).

New Thinking for You

1. Why are plants weakened greatly when caterpillars strip them of leaves?

2. How does animal life help green plants to get food?

3. Why would human beings and all animals soon starve if the sun were to stop shining?

4. Explain how plants in an aquarium help the fish, and how the fish help the plants.
5. Why should plants not be left in a bedroom at night?
6. How do plants make the atmosphere in the classroom more healthful?

Try To Find Out

1. Is it the leaves or the stems of house plants in a window that bend towards the light?
2. What effect has shade upon flowers or vegetables growing under trees in a garden?

A Review Exercise

Complete the following table to compare a green leaf as a factory with a chocolate factory (or other local kind). Insert under the heading *Needs* the following: *Workshops, Machinery, Power, Raw materials, Transportation systems, Manufactured products, Waste substances, Working hours.*

Chocolate Factory	Needs	Leaf Factory
Various kinds of rooms	Workshops	Cells in the leaf

◆

Read

Compton's Pictured Encyclopedia: "Plants and How They Make Their Living", Vol. 11, pp. 286-298.

16 mm. Sound Films

Climbing Plants (SB-5)	Dandelion (SN-23)
Plants, How They Feed (SB-6)	Roots of Plants (SN-66)
Life Cycle of Plant (SB-7)	Plant Growth (SN-61)
Roots (SB-9)	Leaves (SN-46)

Ontario Visual Education Branch.

Roots
How Plants Feed
Associated Screen News Limited, Toronto.

Film Strips

Climbing Plants (colour) (with manual)
Ryerson Film Service, Toronto.

3

PLANTS PREPARE FOR THE FUTURE

PLANTS, like ourselves, change their ways of living from season to season to meet new conditions. They also prepare in advance for these seasonal changes.

Plants have special problems in winter. They must withstand low temperatures, frozen ground, drying winds, and sudden changes in weather. Few plants can continue their work under these conditions, so they rest. Their structures and habits must protect them while they do so.

Springtime brings back warmth, moist soil, and other favourable growing conditions. If plants are well prepared, they can take advantage of these conditions to begin growth immediately. This chapter shows us how plants prepare for, and fit themselves into, these changing conditions.

Plants Use and Store Food

Plants use food to grow. Much of the starch, sugar, and other plant foods manufactured in the leaves is used immediately to keep all parts of the plants growing. Plants require a large amount of food to produce flowers and fruits. For this reason they often stop growing in height when they produce flowers, as when wheat and oats "head out". Flowers should be picked regularly from foliage plants so more of the plant food may be used to produce attractive leaves.

Plants use food to make buds for future growth. Trees and shrubs that shed their leaves in autumn must have buds to produce new leaves in spring. These are nourished by food manufactured in the late summer. So are the buds on the underground parts of ferns, rhubarb, and other plants that die down to the ground in autumn.

Plants store food to enable such buds to open in spring. This food must be stored in the plants in autumn. It is contained in the roots of rhubarb, in the underground stems of ferns, and in the roots and stems of trees and shrubs.

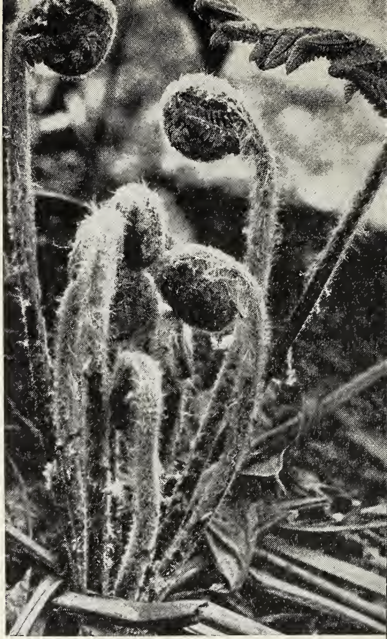


Fig. 3-1. New Fern Leaves ("Fiddle-Heads") in Spring. To produce these new leaves in spring the underground stems of ferns must form buds and store food in autumn.

PLANTS STORE DIFFERENT KINDS OF FOOD. Four foods commonly stored by plants are: starch, sugar, fats or oils, and proteins.

EXPERIMENT 3-1. How can we test for the presence of starch?

Place one or two pieces of laundry starch in a test tube or small bottle. Add two inches of water and shake the tube well. Now add two or three drops of tincture of iodine. See fig. 3-2. What colour does the mixture become?

Starch is turned blue by iodine. No other substance is known to become blue in the presence of iodine. Therefore, if any part of a plant becomes blue when iodine is added to it, we can safely conclude that it contains starch.

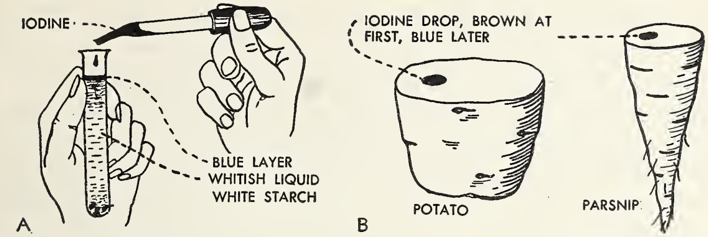


FIG. 3-2. PLANTS STORE STARCH.
A, the test for starch; B, showing that potato tubers and parsnip roots contain starch.

EXPERIMENT 3-2. Test some parts of plants for starch.

(a) Place a drop of iodine on the freshly-cut surface of a piece of potato. What colour is produced? Did the potato contain starch?

(b) Use the same test to discover whether there is starch in the roots of parsnips, carrots, and dahlias; in the bulbs of tulips and daffodils; in soaked seeds of corn and wheat; in the underground stems of ferns and quack grass. Which contain starch?

EXPERIMENT 3-3. Do any plants contain sugar?

Taste the sweetness of sugar. Taste a piece of sugar beet and several fruits. Which contain sugar?

EXPERIMENT 3-4. Test plants for fat or oil.

Rub a little oil or grease on a piece of white paper. Notice the appearance of the "grease spot". Place a drop of olive oil on paper. Crush a peanut or soybean on paper. Which of these contain fat or oil?

EXPERIMENT 3-5. A test for protein.

Feathers and wool contain protein. Burn one of these and notice the smell. This is a test for protein. Burn peas, beans, and peanuts. Notice the smell. Which contain protein?

PLANTS STORE FOOD IN DIFFERENT PARTS AND FOR DIFFERENT PURPOSES. Different plants have different ways of storing food. The method depends to a large degree upon whether the plant lives one year, two years, or more than two years, also upon how it spends the winter.

Annuals and Biennials. An *annual* plant completes its life in one year or growing season. It starts from a seed in spring, grows to mature size, and produces flowers which develop into fruits containing seeds; then it dies. A seed is the only stage of an annual plant that can withstand winter conditions and later produce a new plant. It is adapted in two ways to grow, usually in spring. Part of it is a tiny plant which rests through the winter until the moisture and warmth of spring cause it to start growing again. The remainder of the seed consists of stored plant food ready to nourish the young plant in spring until it has green leaves and can make its own food. The seed has a tough outer cover which protects the inner parts in winter. Most seeds contain so little moisture that freezing does not injure them.

A *biennial* plant, as the name suggests, lives through two years or growing seasons. A carrot is a good example. During the first summer it grows from seed and produces leaves and a fleshy root filled with stored food. In autumn the top dies down, but the root can live through the winter.

EXPERIMENT 3-6. Observe how a garden carrot begins growth a second time.

Plant a stored carrot in a pot of soil. Keep it moist and in a warm place. Where does growth begin? After several weeks, notice how the root has withered.

In the second spring a carrot root produces stems and new leaves. The old root shrivels as it gives up stored food to nourish the new growth.

After the leaves, come flowers and seeds. Then the whole plant dies, leaving the seeds to start new plants. Other biennials that live in a similar manner are: parsnip, turnip, mullein, hollyhock, sweet William, and the clovers.

Perennials. A plant classified as a *perennial* has special adaptations which enable it to survive winter weather and live more than two years. It may produce flowers and seeds from year to year after it has become old enough to do so. The wild aster, Canada thistle, and garden peony are typical perennials.

A perennial plant must have some part or parts which can survive winter conditions, and buds on these to produce new growth in spring. It must also store food to nourish the first spring growth until the new leaves can make their own food. See fig. 3-1.

Herbaceous Perennials. Only the underground parts of ferns, asters, rhubarb, and peonies live over winter. The parts above the ground die down in fall because they are too soft and tender to withstand frost. Such plants are called *herbaceous perennials.*

PUPIL INVESTIGATIONS. Find out how some common herbaceous perennials prepare in autumn for new growth in spring.

(a) Examine the tops of the root systems of rhubarb and peony plants for new buds.

(b) Dig up a fern plant in the wood. Find new buds at the end of its underground stem. Test a slice of it for starch.

(c) Examine the tops of the roots of goldenrod or other wild flowers or weeds for new buds.

The underground parts of peony and rhubarb plants are thick, fleshy roots. In autumn they form buds, ready to produce new growth in spring. The food stored within gives the young plants a good start.

The *bulbs* of tulips and daffodils, and the *corms* of gladioli, trilliums, and jack-in-the-pulpit plants also form buds and store food in autumn, ready for spring's awakening. The thick underground stems (*rhizomes*) of ferns, iris, and quackgrass have well-developed buds and a good supply of stored food before winter comes. A common potato is merely the enlarged end of an underground stem, and is called a *tuber.* The "eyes" are buds from which new plants grow. As the stored starch is used up to nourish the young plant, the potato tuber shrivels.

Woody Perennials. Both the roots and the stems of trees and shrubs are woody. Therefore the stems of these plants, as well as their roots, live over winter. Such plants are called *woody perennials.* The bark protects their inner parts from injury and loss of sap. Buds on the ends of all twigs, and on the sides of some, protect the tender growing tips in winter, and produce new twigs and leaves in spring.

PUPIL INVESTIGATIONS. How are buds adapted to serve trees and shrubs?

Examine buds of a horse chestnut or other tree. Notice how the outer scales overlap enough to shed rain and keep in sap. Is there a varnish-like coating? What purpose could it serve? Remove the outer scales and look for a woolly insulating layer, then a tender growing tip in the middle. You may find tiny leaves and flowers folded within, ready to grow in spring.

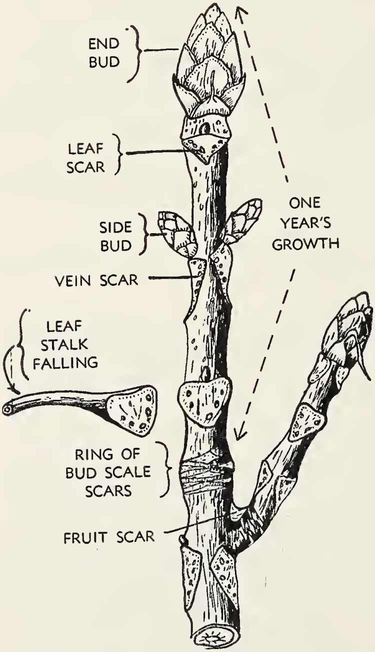


Fig. 3-3. Reading the Story Told by a Horse Chestnut Twig.

The buds of trees and shrubs are formed in late summer. When winter arrives, they contain little leaves and stems, and sometimes flowers, ready to grow in spring. The food needed for this new growth is stored in the roots, trunks, and branches, then flows in the sap to the opening buds when warm weather returns.

Most woody plants shed their leaves in autumn; they are therefore called *deciduous* plants. Other trees and shrubs, called evergreens, retain their leaves and remain green throughout the year.

The habit of shedding their leaves in autumn enables deciduous trees and shrubs to survive winter conditions. We learned in chapter 2 that green leaves are always giving off water. However, trees and shrubs absorb very little water from cold soil, and none from frozen ground. If leaves were to remain on them in winter and continue to give off water, the trunks and branches would dry out and the plants die. The trees in some regions where there is a long dry season prepare for it by shedding their leaves. Thus they avoid the same danger of drying out.

PUPIL INVESTIGATIONS. How do trees prepare to shed their leaves?

Remove some leaves from a tree which has begun to shed its leaves, and from a petunia or other herbaceous plant. From which do the leaves come off more easily? Notice how smooth and dry are the scars left on the tree. Compare them with those on the other plant.

Trees and shrubs prepare well to shed their leaves. First, they withdraw the food from them into the branches. Then they form a thin corky layer between the leaf stalk and the twig, letting the leaf separate easily. This waterproof layer seals the scars and keeps in the sap. How wonderfully Nature has planned and timed such habits as that of leaf fall!

Evergreen trees and shrubs are well protected for winter. Their leaves, like needles or small scales, do not give off enough water to harm the tree. Their needles have such thick, gummy sap (*resin*) and such tough outer coverings that winter does not harm them. Because the leaves of evergreen trees and shrubs remain unchanged in winter, they are ready to make food for the plant whenever the weather becomes favourable.

Though evergreen trees and shrubs are always green, their leaves do finally fall. The carpet of dead needles under a pine tree shows us this. When needles become two or three years old, they fall off, leaving the younger ones to make the plant's food.

Plants Reproduce Themselves

SEEDS REPRODUCE PLANTS. Every plant, including trees, has two jobs in life: to remain alive, and to produce new plants to follow it when it dies. To live and grow, a plant must get or make its own food. Its roots, stems, and leaves enable it to do this. To reproduce themselves most plants form seeds. Flowers make this possible.

Flowers Produce Seeds. The flowers of a plant appeal to us through their colour, size, and perfume, but their chief value to the plant is that they produce its seeds. A careful examination of a garden flowering plant will help us to discover the important role each part of a flower plays in this work.

From What Are Seeds Formed? We can answer this question best by studying seed pods and flowers while we use our text and the diagram (fig. 3-4) as a guide.

Obtain a branch of a petunia plant bearing seed pods and flowers. Find a ripe pod containing seeds. Now find a younger seed pod, still green. Look in the centre of the flower for a tiny pod-like part. This is the beginning of a seed pod. The illustration names this part for you. It is called the *ovary*.

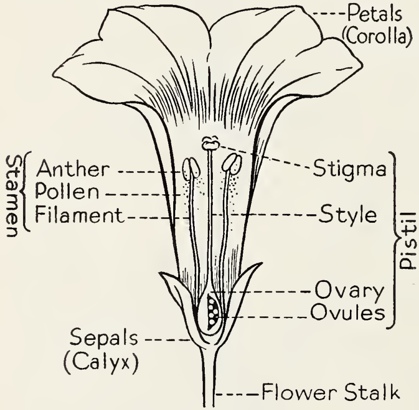


FIG. 3-4. THE PARTS OF A PETUNIA FLOWER.

Notice the colour and size of the seeds in the ripe seed pod. Now open the green seed pod. Compare the green seeds in it with the ripe ones, particularly as to colour and size. Now cut through the ovary in the centre of the flower. Look in the ovary for little objects resembling green seeds. These are not yet seeds; they are *ovules*, having the power to become seeds.

Ovules need help to become seeds. The yellow powder, called *pollen*, which we often see in flowers, provides this help. It is produced by the *anthers*, the knobbed parts at the top of the *stamens* which surround the ovary. Find these stamens and their anthers in your flower, using the diagram as a guide. Later in this chapter we will learn how the pollen helps the ovules to become seeds.

The ovary and stamens, essential in the making of seeds, need protection from rain, dew, and injury. This is especially true when the flower is in the bud stage. The large, showy, coloured *petals* that make up the *corolla* (little crown) usually protect the stamens and ovary by being wrapped closely around them. The spaces between the petals are usually covered by small, green leaves called *sepals*. These make up the *calyx* (cup) of the flower. Find the corolla and calyx (the petals and sepals) in your flower and in fig. 3-4.

PUPIL INVESTIGATIONS. Examine the flowers of several kinds of plants to discover:

(a) ripe and green seed pods;
(b) their ovaries and stamens;
(c) their petals and sepals;
(d) how their petals and sepals are arranged to protect the ovaries and stamens from damage by rain or by injury.

How Does Pollen Help Flowers To Produce Seeds? To answer this question we need to know how to talk about the other parts of a flower. Examine a petunia flower while using fig. 3-4 as a guide. Find the ovary again. Look above it for a slender stalk, the *style*, holding up a sticky knob, the *stigma*. These three parts — ovary, style, and stigma — make up the *pistil* of a flower. They work together to help the ovary produce seeds.

We have learned that the ovules of a flower can produce seeds only with the help of pollen. The pollen must be carried to the stigma of a flower. This carrying of pollen from a stamen to a stigma is called *pollination.* In some flowers the stamens and stigmas are close enough that the pollen falls from the stamens to the stigma. Wind carries the pollen of corn plants and of several grasses and trees. While bees are gathering nectar from flowers, they often carry pollen from one flower to another.

PUPIL INVESTIGATIONS. How is a flower adapted for pollination? Examine some pollen grains through a magnifying lens or a microscope. Feel the stickiness of the stigma of a petunia or geranium plant. With a fine paint brush transfer some pollen from a ripe stamen to a stigma of a petunia or geranium flower on a plant. Notice how the pollen sticks to the stigma. Watch for seeds to form.

A pollen grain is a living thing. Soon after it reaches the sticky liquid on a stigma, it produces a tiny tube called a *pollen tube.* This grows down through the pistil until it reaches an ovule. When the pollen tube and ovule have combined by a process called *fertilization,* the ovule becomes a seed. Then this seed grows and ripens. The ripe seed contains a tiny new plant, a supply of stored food, and a protective cover. The pod or fleshy part of the plant containing the seed or seeds is called a *fruit.*

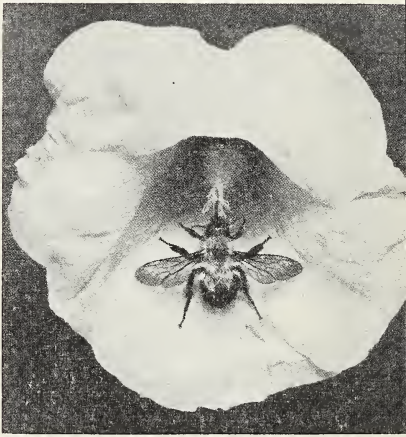
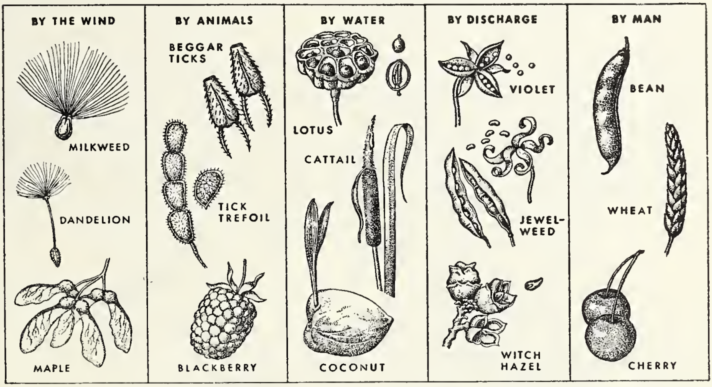


FIG. 3-5. A BUMBLEBEE VISITING A HOLLYHOCK FLOWER.

Seeds Must Be Scattered. Plants must have enough space, moisture, food, and light to grow well. If all the seeds from a maple tree or a pigweed or petunia plant were to start growing where they fell beneath it, only a few of the stronger ones could survive. None of these would get enough moisture, food, or light to grow well.

A walk along the roadside, in fields or gardens, or even in wooded places, will help us to see for ourselves some of the clever ways in which seeds become spread. We should watch for two things in particular: how the seeds or fruits of a particular plant are scattered, and how their structure fits them to be scattered in this way.

Some Seeds Are Carried by the Wind. Maple seeds flutter down and away from the tree in even a slight breeze. Two light, but strong, flat wings carry them along on the moving air. The one wing on the seeds of elm, pine, and spruce is enough to carry them. The hairy tufts of dandelion and milkweed seeds serve well as parachutes. Pigweed plants are rolled along the ground by wind, dropping their seeds as they go. When poppy pods sway back and forth in a breeze, they throw out their seeds through the little openings in the pods. See fig. 2-5.



(*Compton's Pictured Encyclopedia*)

FIG. 3-6. SEEDS ARE SCATTERED IN MANY DIFFERENT WAYS.

Some Seeds Are Carried by Animals and Man. Burs may be carried far afield when their little hooks or barbs catch in the coats of dogs and sheep or in our clothing. When birds eat such fruits as cherries and blackberries, they scatter the undigested seeds wherever they fly. Mud clinging to the legs of birds or other animals often contains seeds and deposits them wherever the dried soil falls. Man carries weed seeds from field to field and from farm to farm in hay and grain and on his farm machinery.

Water Is a Carrier of Seeds. The seeds of ragweed and dock are light enough to float easily in the water that drains from one field to another, and in creeks and rivers to more distant places.

Some Plants Shoot Their Seeds Away from Them. When you squeeze a seed pod of garden balsam or wild touch-me-not, the seeds are thrown considerable distances. Likewise, the pods of beans and peas, when ripe and dry, break open, twist, and scatter their seeds. The seeds of wild geranium and witch hazel are scattered in a similar manner.

SPORES REPRODUCE PLANTS. Some plants such as ferns, mosses, mushrooms, bread mould, potato scab, and oat smut do not produce flowers. Instead of seeds, they produce *spores*, tiny living things as small as dust particles. The under side of the leaves of fern plants often bear irregular, rounded objects called fruit dots. A lens will show that each is a collection of tiny, stalked cases containing dust-like spores which are blown

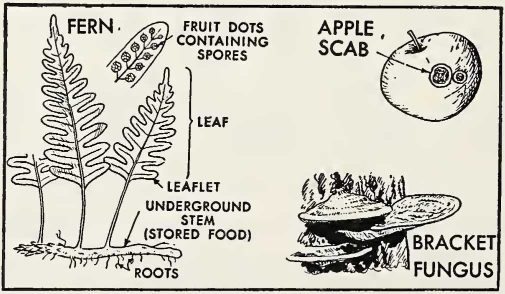


Fig. 3-7. Plants That Reproduce by Spores.

about and produce new plants. Moss plants produce slender, upright stalks bearing small spore-filled cases at the top. If the top is cut from a ripe mushroom and placed right-side-up on white paper, a pattern of spores will be left by it. Similarly, the black specks in bread mould and oat smut consist of spores — all capable of producing new plants. See fig. 3-7.

PIECES OF THE PARENT PLANT MAY PRODUCE NEW PLANTS. Some plants multiply or reproduce themselves without forming either seeds or spores. A part of the parent plant produces another new, but complete, plant. In our homes and gardens we have copied many of nature's methods of producing new plants from pieces of the old ones. This production of new plants without seeds is called *vegetative reproduction.*

Cuttings. A cutting or "slip" is merely a piece of a plant placed where it can go on growing and start a new plant. Some kinds of plants are reproduced or *propagated* by using pieces of the stem (*stem cuttings*); others, by using merely a leaf (*leaf cuttings*).

Stem Cuttings. A cutting of geranium, coleus (often called "foliage plant"), begonia, or wandering Jew, properly made and cared for, soon produces a new plant similar to the parent. Cuttings made in early spring will produce plants for the garden. If planted in early September, cuttings will produce good indoor plants for winter.

EXPERIMENT 3-7. Make and plant a geranium cutting.

Select two or three joints at the end of a comparatively new branch, but mature enough to break when bent sharply. Use a sharp knife to remove the cutting with a clean, slanting cut just below a joint. Remove from it all flowers and flower buds and all but two or three ordinary-sized leaves or one large one. Plant the cutting firmly in moist sand, covering one joint well. Place the pot in a warm, shady place, and keep the sand moist. Transplant it to a pot of good soil as soon as new leaves indicate that roots have developed.

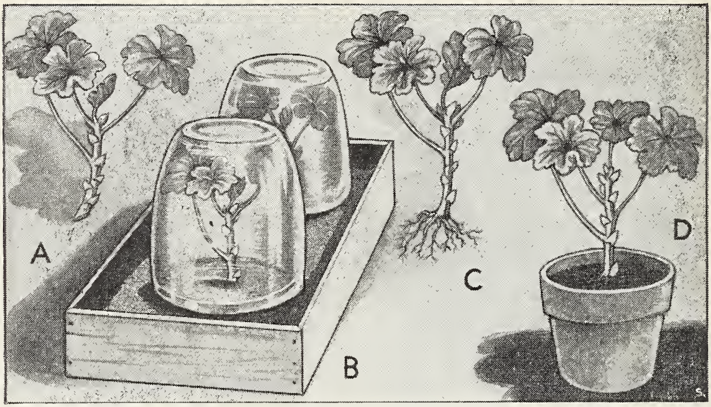


FIG. 3-8. GROWING NEW GERANIUM PLANTS.

A, a cutting ready to be planted; B, cuttings planted in sand and covered to retain moisture; C, a cutting rooted and growing, ready to be potted; D, a young geranium plant showing more growth.

Stem cuttings may be planted to produce new plants of rose, willow, grape, currant, and some flowering shrubs. Pieces six to ten inches long should be cut in autumn from firm wood of the same year's growth, and stored in damp sand in a cool place above freezing point. In spring these should be planted outdoors with one bud exposed to produce a new stem and leaves.

When we plant a piece of potato with two or three "eyes" on it, we are really planting a stem cutting bearing buds.

Leaf Cuttings. Two common house plants, begonia and African violet, may be propagated from single leaves, as leaf cuttings. Cut the main veins of the rex begonia leaf on the under side in several places, then lay the leaf flat on moist sand. Anchor it there with sand or pebbles. New plants will start where the veins are cut. Other begonias may be propagated by inserting the stalk of a leaf in moist sand to half its length. The leaves of African violets should be set deep enough in sand to cover nearly half of the leaf stalk.

Root Division. New plants of many perennials are produced by dividing the root of a large plant into several parts. Dahlia roots should be cut apart so that each root has a piece of stem with one or more buds. The divided parts of the roots of rhubarb, daisies, phlox, larkspur, and iris may be of any desired size, but must bear buds. Each is transplanted to the depth at which it was previously growing.

Bulbs and Gladioli. When tulips are left in the ground from year to year, small bulbs (bulblets) form around the parent ones, then grow to mature size. The bulbs should be dug up and transplanted in smaller groups every two or three years. A gladiolus corm may produce several smaller ones beside it each summer. Crocus corms multiply similarly.

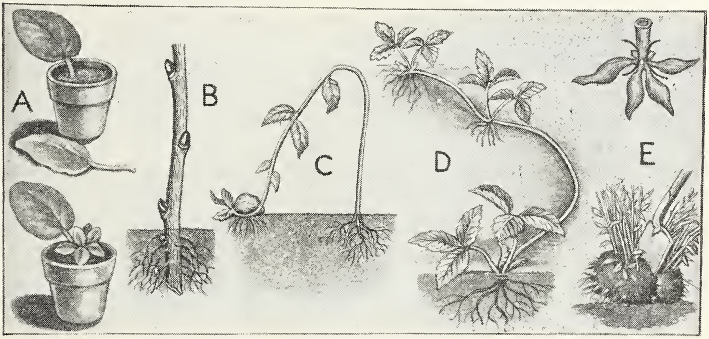


FIG. 3-9. SOME WAYS OF PRODUCING NEW PLANTS.

A, a leaf of African violet planted in sand and kept moist to produce a new plant; B, a hardwood stem cutting of a flowering shrub; C, producing a new blackberry plant by tip layering; D, new strawberry plants formed by a runner from the parent plant; E, dividing the roots of dahlia and phlox plants. See also grafting, fig. 1-10.

Runners. Strawberry plants send out long, slender horizontal stems called *runners,* which take root at the end and produce a new plant. Even a new plant, so formed, can immediately send out a new runner.

Layering. A stem of black raspberry may be bent over and its tip buried in soil and anchored by a stone. It will take root and send up a new plant while obtaining food from the parent plant. Then the old stem may be cut. Grapes, currants, and some flowering shrubs may be propagated in a similar manner.

Grafting and Budding. A bud or a piece of a stem of a McIntosh apple tree may be *grafted* to a snow apple tree and grow to produce a new branch. This branch will bear McIntosh apples only. Named varieties of other kinds of fruit trees are produced for sale in this manner. Similarly, buds may be grafted onto briar roots to produce named varieties of roses.

Review Exercises

1. Under each other, copy each of these names of plants: begonia, strawberry, buttercup, willow, peony, apple, potato, onion, geranium, fern, African violet, rose, black raspberry. After each, write one or more letters (A, B, etc.) to indicate by which of these methods it is usually propagated: A. root cuttings; B. stem cuttings; C. bulblets; D. leaf cuttings; E. runners; F. layering; G. seeds; H. spores; I. root division; J. grafting.

2. Rule the following table in your notebook, then fill in the names of as many of the plants listed below it as you can. You should have at least two names in each rectangle.

	Annual	Biennial	Perennial
Garden or Wild Flowers			
Vegetables or Fruits			
Weeds			
Field crops			

Plants: barley, red clover, dandelion, chrysanthemum, dahlia, hollyhock, carrot, corn, radish, petunia, wild mustard, corn, burdock, alfalfa, tulip, asparagus, rose, cabbage, foxglove, lamb's quarters, sweet clover, alsike clover, snapdragon, ox-eye daisy, apple, mullein.

Questions

1. Explain what you understand by: annual, biennial, perennial, woody perennial, evergreen plant, herbaceous perennial.

2. (a) How do trees prepare to shed their leaves?

(b) What is the advantage of trees shedding their leaves at the approach of winter?

(c) Why is it unnecessary for evergreen trees to shed all of their leaves at the approach of winter?

3. Tell how the following prepare for both winter and spring: maple trees, peony or rhubarb plants, carrot or beet plants.

4. What two things must any perennial plant have if it is to begin new growth in spring?

5. What do biennials produce the first growing season? The second?

◆

Read

Compton's Pictured Encyclopedia: "Flowers" (several articles and 66 coloured plates), Vol. 5, pp. 168-187.

16 mm. Sound Films

Flowers at Work (SN-29)
Growth of Flowers (SG-12)
Seed Dispersal (SN-68)
Seed Dispersal by Animals (SN-69)
Seed Dispersal by Wind (SN-91)
Ontario Visual Education Branch.
The Growth of Flowers (colour)
Seed Dispersal
Associated Screen News Limited, Toronto.

4

LET'S USE PLANTS TO BEAUTIFY OUR SURROUNDINGS

Come forth into the light of things,
Let Nature be your teacher.

Wordsworth

Using Plants Outdoors

WHETHER WE LIVE IN CITY OR COUNTRY, plants make up much of the beauty surrounding our homes. We learned about this in chapter 1. Turn again to page 7 and read the section entitled "Plants Beautify the Earth". Recall also what you discovered by your personal investigations of the plants around you. Then study fig. 4-1.

PLANNING ATTRACTIVE GROUNDS. Sit back. Close your eyes. Picture the surroundings of your school as beautiful as you can imagine them. Write out your ideas while other pupils do likewise. Some will prefer to illustrate theirs by drawings. Discuss different suggestions, then make a blackboard summary of your plans. Now you know better what kind of help you need from others.

Sources of Information. Most of us can use the help of specialists in planning grounds which will be both useful and beautiful. Even the most experienced gardeners are constantly finding new and better ways of planting and making gardens. Let us get their suggestions before we complete our plan. Besides consulting these people, we can visit attractive grounds around homes or around other schools and get valuable ideas. Pictures and descriptions in magazines, books, and catalogues will show us plans that others have followed.

Members of horticultural societies are likely to know much about the planning and making of gardens. The County Agricultural Representative is trained to advise us in such matters. The Home and School Association and its members will take a helpful interest in our objective. The manager of a nursery

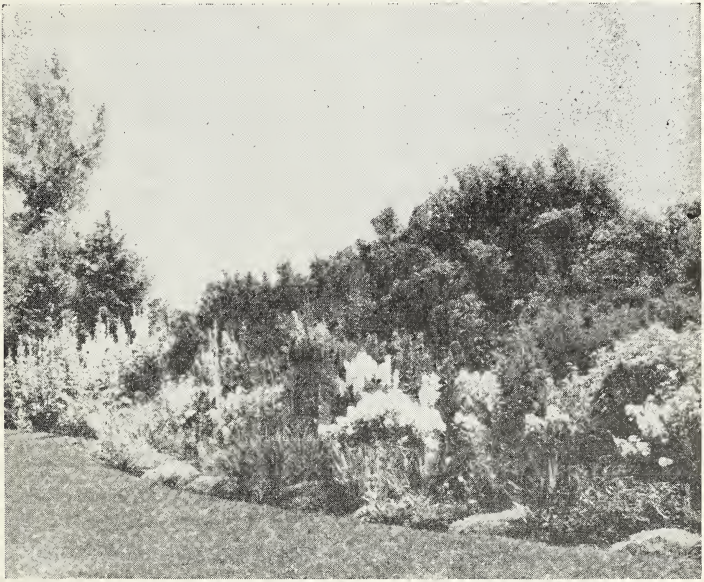


FIG. 4-1. AN OUTDOOR LIVING ROOM.

The lawn, a soft rug; low, medium, and tall flowering plants, representing beautiful ornaments and graceful furniture; shrubs and trees, like drapes in the background.

will probably be pleased to draw a plan of how the school grounds may be beautified.

Making the Plans. Whoever is to draw the final plan to improve our school grounds must know what they are like now. He must have a sketch showing directions, the over-all dimensions of the grounds, the position and kind of each existing tree and shrub, the exact position and size of each building, and the locations of walks and playing areas. This sketch will show him what conditions his plan must fit, and what he has to start with.

Our first task, then, is to make all the necessary measurements. Knowing the size of the paper on which the plan is to be drawn, we can decide what scale to use. An inch on our plan may represent 25 feet in the school grounds. After the outline is drawn to scale, the school building should be sketched in the correct location with its size to the scale we are using. Walks, play grounds, and garden areas should then be added. Now we are ready to make the final plan for the beautification of our grounds.

Well-planned grounds, at school or at home, will be both useful and beautiful. They should serve our needs and, at the same time, look attractive. Most school grounds need shrubs and flowers around the building, an attractive front yard, an adequate play ground, a bordering fence or row of trees, and a vegetable garden. Each of these must be carefully planned to serve its own special purpose and to contribute its share to making the grounds as a whole look their best.

The building is the centre of interest. Shrubs growing around it will make it fit into its surroundings so that it will appear to be a real part of the school grounds, not merely a building resting in them. Shrubs planted around the building for this purpose make up what we call a *foundation planting.* A few bulbs or other flowering plants among or in front of the shrubs will add colour. This planting should be at least four or five feet wide.

The front yard of the school, as at home, should appeal to the eye whether we look at it from the front door or from the street or road. The front of the building should be attractively framed or ornamented with shrubs. These will also make an interesting background if planted along the fences around the front yard. Of course, the main area will be a well-cared-for lawn. Walks or paths, whether of cement, flag-stone, or gravel, should follow the shortest route in a straight or gently curved line from the front of the yard to the door.

Naturally we will want some flower beds containing perennials or annuals or both. They should be at least three feet wide, and will look best in front of the building, along the pathway, or in front of the hedge or shrubs around the yard.

Stop reading now until you have drawn a plan, perhaps in colour, to show how you would like the building and the front yard to appear.

The fence, trees, or hedge around our grounds give passers-by their first impression of our school or home. They are like the frame around a picture. Is the fence neat, attractive, and in good repair? Do trees add beauty and give shade? We should consider these in our plan for beautification.

The planning of useful play areas is important. Of course, we want these to be large open spaces, level enough for games. Paths, trees, or shrubs which would interfere with games are to be avoided. Although we do not call this area a lawn, it is best covered with tough grass.

The place selected for the school garden must meet the needs of cultivated plants. The soil in it must be well drained and fertile enough for good growth. It should be so located that trees neither shade the vegetables nor rob them of food. The size of our school garden will depend upon the number of pupils who will be working in it, the uses we are to make of its products, and how it is to be cared for in summer holidays.

Now we know better how to draw all parts of our plan to scale. Let us do so. In spring we can decide what plants to grow and how to arrange them.

AUTUMN ACTIVITIES ON THE GROUNDS. Our plan for improving our grounds will be useless so long as it is merely a drawing on paper. Let us all go to work now to do those things which can be done in autumn.

The beautification of our school grounds will also interest trustees, parents, and neighbours. They, too, will want their school to look as attractive as their own homes. Pupils and teacher can carry out many of the necessary tasks. Trustees can provide tools and supplies. All can work together as a "bee", a gathering of parents and neighbours at the school to help with the work. They may bring tractors or teams of horses, ploughs, graders, and shovels — all the implements needed for the work.

Tidying Up the Yard. The first essential in producing more attractive grounds is to make all parts of them look as neat and tidy as possible. Let us start by gathering up and taking away all loose sticks, stones, and pieces of paper. Then such unsightly remains as dead annuals, the tops of perennials, overgrown grass and weeds, and dead branches of trees and shrubs should be collected and safely burned. The help of trustees and parents will be needed for such improvements as straightening up a leaning flagpole, tightening wire fences, and repairing or painting wood fences and outbuildings.

Preparing Areas for Planting in Spring. The soil where shrubs, garden flowers, and vegetables are to be planted in spring should be prepared in autumn. These steps should be followed. Mark off the areas according to the plan drawn. Remove all bricks or other refuse. Spade or plough the soil to a depth of a foot or more. Bury all sod and work well-rotted manure into the soil. Add fertile soil if necessary. Leave the surface rough so that frost may have a better chance to improve the soil. Thorough preparation of these planting areas will cause better growth for years to come.

Autumn Work on the Lawn. We can help a well-established lawn to survive winter conditions. If we stop mowing it early enough, it will have a dense growth of grass at freezing time. To this we should add a thin but even layer of well-rotted barnyard manure. These coverings will prevent the grass from starting growth with early spring thaws. The manure will also add nourishment. New lawns may be planted in autumn. September is the best month to do so. Then the new seedlings, helped by autumn rains, will get a good start before the ground freezes.

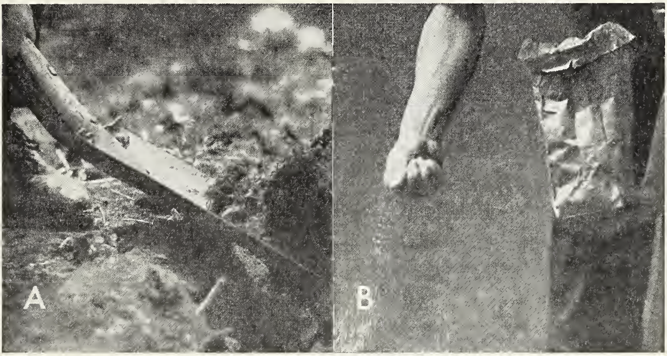


FIG. 4-2. MAKING A LAWN.
A, spade deeply; B, sow thickly.

To build a new lawn the instructions to be given here will be found helpful. Remove all stones and rubbish from the area. Cultivate the soil deeply and thoroughly. Work in some well-rotted manure unless the soil is quite fertile. If the soil at hand has come from an excavation, or is naturally poor, mix some good topsoil with it. Then level the whole area carefully to fill in any low spots.

Use seed recommended by a good gardener or a seed merchant. It is easier to scatter the seed evenly if we mark off the lawn in strips about three or four feet wide and sow each strip separately. Always sow grass seed when no wind is blowing. One pound of seed will sow about 200 square feet. Cover the seed either by sifting a thin layer of soil over it or by raking the soil lightly and evenly.

The newly sown lawn area must never be allowed to become dry. Watering should be done only by a fine spray, and always thoroughly. The new grass should not be cut until it is three to four inches high. Grass clippings should be left on the lawn unless there are so many that they will appear too unsightly.

Planting Bulbs and Other Plants Out of Doors in Autumn. *Bulbs.* For bloom in spring most bulbs are planted in autumn. Tulips, daffodils, and narcissi, having the most showy flowers, look well in borders and among shrubs. Hyacinths are grown for their delicate flowers and their sweet perfume. Crocuses growing in the grass beautify the lawn. All of these will bloom before other plants have had time to produce flowers.

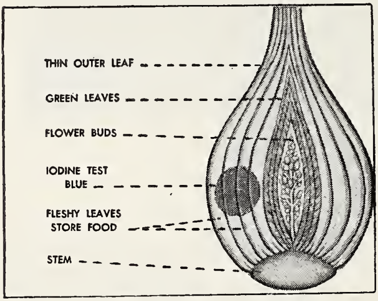


FIG. 4-3. A DAFFODIL BULB.

A bulb can produce leaves and flowers quickly because it contains a supply of stored food and new leaves and flower buds ready to grow.

PUPIL INVESTIGATION. How are bulbs fitted to produce leaves and flowers so early in spring?

Cut a tulip or a daffodil bulb down through the centre. Look for new, delicately coloured leaves and the long, slender, yellowish stamens which are to become a part of the flower. These need food to develop. Is there food stored in the bulb? To find out, put a drop of iodine on the thick fleshy leaves. What do you conclude?

Bulbs planted out of doors in autumn produce roots until the soil is too cold. Throughout the winter they rest. As soon as the ground warms up in spring, their roots help them to develop leaves and flowers.

We are tempted to cut or dig up the bulb plants when they have finished flowering. We should not do this. Being perennials, they must be given a chance to make the food necessary to produce the tiny new leaves and flowers in their bulbs for next year and some extra food to be stored until needed for their growth. Only their green leaves can make this food. Therefore, we must let these plants go on growing for several weeks after they have finished flowering in spring.

Bulbs may be planted in rows, in beds, or in groups of five to ten. Dig the soil deeply, loosely, and thoroughly to a depth of about eight inches. Make the holes about seven inches deep. Loosen the bottom soil and arrange the bulbs on it about three inches apart. Carefully cover them with soil and pack it lightly. Annual plants may be grown over these, and the soil kept cultivated without harming them.

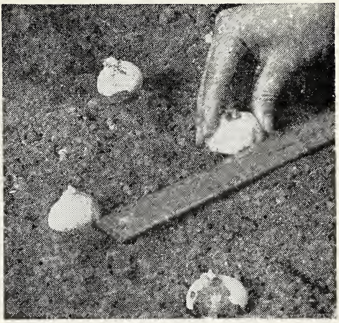


FIG. 4-4.
PLANTING BULBS OUTDOORS.
The bulbs in a clump should be about six inches apart.

Other Perennials. Hardy perennials that bloom early in spring or that have fibrous root systems may be planted safely in autumn. This applies to rock cress, bleeding heart, daisies, delphinium, and lily-of-the-valley. New plants of these may be produced by dividing larger ones. Never move chrysanthemums in fall.

Protecting Garden Plants in Winter. *Out of Doors.* Some perennials and biennials live through the winter, then are killed in early spring by the alternate thawing and freezing of the soil. We can prevent this by covering the soil around the plants after it has frozen hard in autumn. Suitable covering materials are straw, hay, manure, evergreen boughs, and the removed tops of garden plants. Fallen leaves are not satisfactory. Soil should be banked around roses and peonies to a depth of six to ten inches.

Indoors. The underground roots of dahlias and the corms of gladioli will not survive freezing. They must be stored indoors. Dig these up before the ground freezes. Cut off all but an inch or two of the stalk. Leave them in the sun for several hours to dry. Remove all soil, and decayed or injured parts. Store gladioli in an open box. Place dahlia roots in a box and cover them with sand or sawdust to keep them from drying out and shrivelling up, then store them in a cool place, but where they will never freeze.

Using Plants Indoors

With October days come falling leaves and frosty nights. When the beauty of our gardens has disappeared, where shall we find plants for our enjoyment? Only indoors. We can transplant some from the garden; others we can start from cuttings; still others from bulbs. For any of these we must have good soil.

PREPARE POTTING SOIL. The soil in flower pots must supply the roots with water and other plant foods, also air for them to breathe. To take in water and air, the soil must have enough sand and humus to make it porous. To retain sufficient water for the plants, it must contain the right proportion of fine particles (clay) and a liberal supply of humus. To feed the plants well, it requires humus and manure or other fertilizers.

Potting soil with these characteristics can be made from good garden loam. To it should be added one-quarter to one-third as much well-rotted and well-pulverized manure, and about one-eighth as much sharp sand. The mixture may be enriched by adding leaf mould from under trees, also fertilizers, according to directions. All parts should be thoroughly mixed, lumps crushed, and trash and stones removed with a coarse sifter. Now the soil is ready for potting plants.

A *compost heap* provides a good potting mixture. To make it, pile leaves and garden refuse, sods or good garden loam, and manure in alternating layers, each three or four inches thick. Keep the pile moist. Mix the materials thoroughly every month after they begin to decay. When all parts are well rotted, use this material as potting soil. See fig. 4-5.

POT GARDEN PLANTS. Geranium, begonia, and small foliage plants may be transplanted from the garden and grown indoors. Choose a container of the right size for the plant. Place some broken pottery or cinders in the bottom of the container to permit surplus water to flow freely from the holes. Partly fill it with good potting soil.

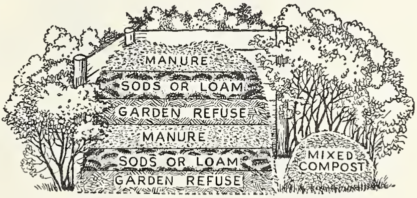


FIG. 4-5. A COMPOST HEAP.
Build the pile with even layers. Sods should be placed face down. The depression in the top holds water from rain, and this aids decay.

Select only small plants, or remove the older stalks of larger plants and use the new growth near the ground. Carefully dig up the plant with a mass of soil clinging to the roots, and place it in the pot so all parts of the roots are at least an inch below the top of the pot. With the finger tips pack more potting soil firmly around the roots until the pot is filled to within three-quarters of an inch of the top. Soak all the soil thoroughly at once. Keep the plant in a shady place for a few days.

GROW BULBS INDOORS. Flowering bulbs — tulips, daffodils, hyacinths, narcissi, crocuses — make attractive house plants. We can have them growing in our homes or classrooms throughout the winter by planting them in autumn and giving them proper care.

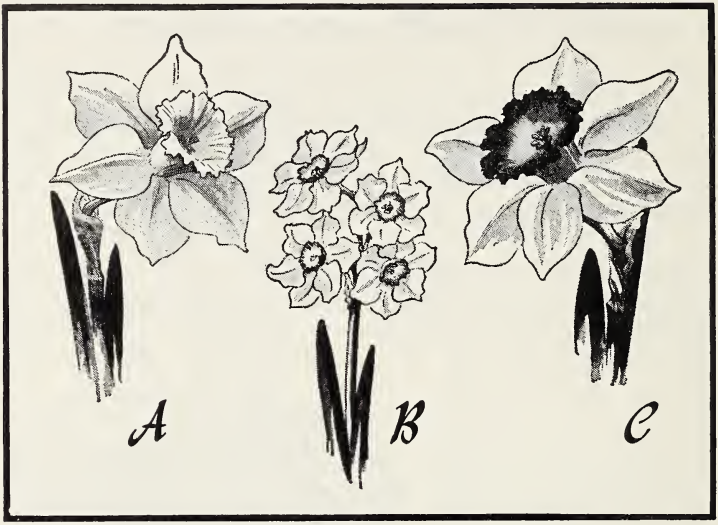


FIG. 4-6. FLOWERS FOR WINTER ENJOYMENT.
A, daffodil with one colour; B, cluster-flowered narcissus; C, daffodil with cup and saucer in different colours.

Planting the Bulbs. Buy only firm and healthy bulbs. Prepare the soil as for house plants. Obtain pots of correct sizes for the bulbs chosen — a three-inch pot for single bulbs, and four-inch or five-inch pots for three or four small bulbs. Place pottery or cinders in the bottom of the pot as drainage material. Fill the pot with loose soil, leaving a space equal to the height of the bulb. Place the bulbs in position but do not push them down. Cover them with soil until their tips are merely visible. Press this soil gently around the bulbs. Leave three-fourths of an inch of space for water. Soak the soil thoroughly.

Producing Root Development. Bulbs must have a large network of roots to produce leaves and blooms. To develop these,

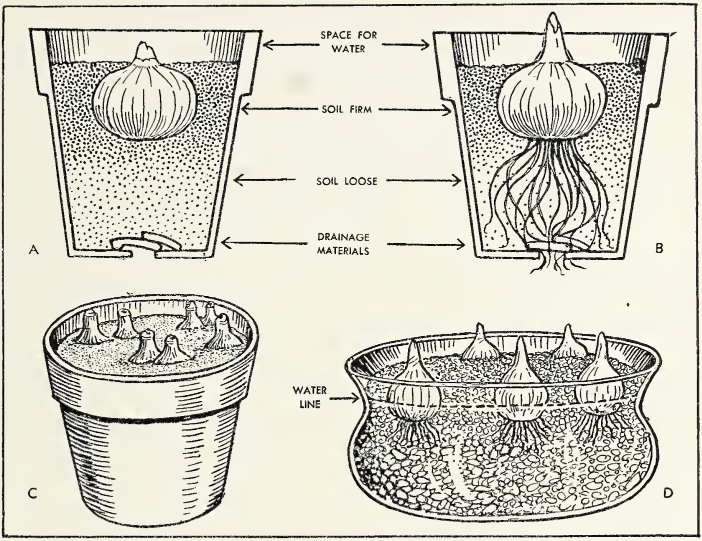


Fig. 4-7. Planting Bulbs Indoors.

A, hyacinth planted; B, hyacinth rooted, ready to be brought from the cold, dark place to a warmer, partly lighted place; C, daffodils potted; D, paper-white narcissi in pebbles and water.

store the planted bulbs in a cool, dark place in the cellar. The soil should be kept merely moist and the plant allowed sufficient ventilation to prevent mould from growing. If potted bulbs are left in these conditions, roots will appear through the hole in the bottom of the pot in about six to eight weeks.

Producing Leaf and Flower Development. The leaves and flowers of well-rooted bulbs will develop best in a warm, bright place. When the roots can be seen at the bottom of the pot, move the potted bulbs from the cool, dark place to a warmer place with some light. In a few days, after the leaves have changed from yellow to green, move the plants to a bright, warm room.

Growing Bulbs in Water. This method of planting bulbs is particularly suitable for paper-white narcissus bulbs. A shallow dish should be half filled with pebbles, the bulbs arranged on this foundation, and then anchored with more pebbles until only their top halves remain in view. Water should be added to such a depth that one-third of each bulb is immersed. Place the bowl in a cool, dark place for good root development. If blooms are desired sooner, leave the bowl in the warmth and light of the room. Paper-white narcissi, properly planted and cared for, will reward us with their clusters of fragrant, pure-white blossoms in about six weeks.

GIVE INDOOR PLANTS GOOD CARE. For successful growth, indoor plants require sufficient water and food, good drainage, sunlight, a suitable temperature, ventilation, and moist air.

Sufficient Water and Food. Water is an essential plant food. It also dissolves mineral materials in the soil and carries them into the plant. Always water plants thoroughly, until all the soil is so wet that some water escapes from the bottom of the pot. They will not need watering again until the top soil looks and feels dry. Too frequently watering removes some plant foods in the water that escapes from the bottom of the pot. If the soil is poorly drained or remains wet too long, air cannot get through it, and the roots of the plants cannot breathe.

Other necessary plant foods are provided by the soil. We can give them additional nourishment by working well-rotted manure into the soil or by feeding the plants fertilizers in tablet or powder form, according to directions supplied with them.

Good Light. Green plants need light to make food. Some house plants need more than others. Geraniums grow best if they are in direct sunlight most of the day. Ferns and wandering Jew grow best in a north window, without direct sunlight.

Healthy Atmosphere. To breathe efficiently, plants need fresh air. Good ventilation gives this. Sudden changes in temperature or draughts of cold air are injurious to most house plants. Indoor air, when artificially heated, is usually too dry for the healthful growth of plants. A teakettle or jar of water on the stove or register will moisten the air, making it more like that in the tropics where most house plants originally grew.

Freedom from Insect Pests. Even healthy house plants, well cared for, may be attacked by injurious insects. The small green, black, or white insects known as *plant lice* (*aphids*) suck sap from the leaves, stems, and flowers of plants. We suffocate them with sprays. White, cotton-like *mealybugs* may be found in the axils of leaves, sucking juices from the plant. These and *scale insects* on ferns may be removed by means of a stiff brush and soap suds.

Some Learning Activities

1. Find out what amount of light is best for geranium plants. Place potted geranium plants (a) in a south window close to the glass; (b) near a south window, but a foot or two from the glass; (c) in a north window. Keep all plants at the same temperature and equally moist. In which place do they grow best? Why?
2. Make a compost heap in the garden at school or at home. Follow the directions given on page 67.

Discuss These Orally

1. What is meant by: foundation planting, perennial, mulch, compost heap?
2. What are the advantages of seeding a lawn in September rather than in July or October?
3. Why do we cover some garden perennials in autumn? When should we? Name three good covering materials.
4. How can we make a soil mixture good for potting plants?
5. A class potted some tulips in good soil, placed the pots in a sunny south window, and kept the soil moist. The bulbs produced leaves, but did not bloom well. What mistakes did the class make in caring for the potted bulbs?

Write Answers to These

1. What are the four important steps to be taken in making a new lawn?

2. What three kinds of bulbs may be grown successfully either outdoors or indoors?

3. In what two ways is a bulb ready to grow quickly as soon as it is given favourable growing conditions?

4. What four conditions must we provide for house plants if they are to grow well?

Conserve Water and Soil in the School Garden

How does the digging of plant remains into garden soil affect the amount of water and of soil lost during heavy rains? Select a sloping part of the school garden. Remove all garden refuse from half of it; then dig the soil and rake it smooth. On the other half, place a thick layer of grass clippings, "strawy" manure, or other garden refuse; dig this into the top layer of soil, and leave the surface rough. From which area does more water run off during heavy rains? From which is more soil carried away by water running off? Which is the better method of cultivation? How could a farmer conserve soil and water on a hillside?

◆

16 mm. Sound Films

Kew
United Kingdom Information Office, Ottawa.

Film Strips

Garden Flowers, Grown from Bulbs (colour) (with manual)
Ryerson Film Service, Toronto.

UNIT TWO

Water: Nature's Great Gift

5. *WATER IN OUR DAILY LIVING*

Water is everywhere, in the earth and on its surface, in the air above the earth, in every living thing. It is essential to life and civilization—in food and drink, in home and community, for pleasure and recreation, for industry and transportation.

6. *THE INS AND OUTS OF WATER*

Water is always changing or working. We see it as snow or ice, or as a liquid; then it disappears as vapour in the air, only to become visible again as rain or snow or frost. Water dissolves sugar in our foods, minerals from rocks, and oxygen from the air.

7. *WATER MUST BE CONSERVED*

Water often becomes too scarce to satisfy the needs of home and community, of crops and livestock, and of industries. We can conserve water by growing forests and grass to make more of it soak into the earth instead of running off, by building dams to create ponds or lakes, and by keeping streams from becoming polluted.

8. *WATER CONTRIBUTES TO HEALTHFUL LIVING*

The water we use in daily living comes from rain or streams or underground sources. Some of it is pure and healthful; some, impure and dangerous. Man has learned how to obtain supplies of safe water and how to use it for healthful living.

The scene on the following page illustrates some of the characteristics and uses of water. How many can you find? You will be able to find more after you have read the four chapters in this unit.

5

WATER IN OUR DAILY LIVING

WITHOUT WATER, we could not exist. It enters into our daily lives at every turn. When thirsty, we drink it. When hungry, we take food containing it. Water makes the air we breathe more healthful. We use it to keep our bodies clean, and to dispose of all sorts of wastes. Water keeps alive the plants and animals from which we derive food, clothing, shelter, and employment.

From earliest times man has always settled near water. The first communities in any new land grow up beside ocean or lake, river or smaller stream. In such places soil and water work together to provide the essentials of living. Here man's crops grow more abundantly, his livestock is more likely to obtain

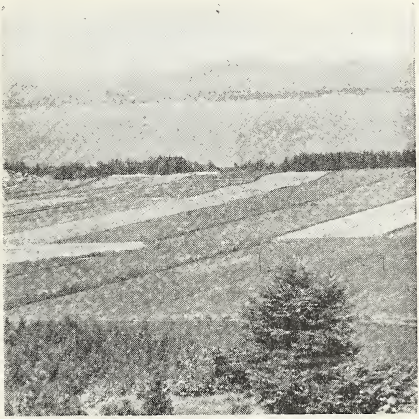


FIG. 5-1. EARLY SETTLERS MADE THEIR HOMES NEAR WATER.

The first French farmers in Canada settled close together along the St. Lawrence River. Their long, narrow farms extended back from the water, as we see them today.

sufficient food and water, and useful wildlife can flourish. By living beside water, man uses it for transportation and power and, at the same time, enjoys the recreational values of swimming and boating.

Water is "the lifeblood of civilization". Where there are ample supplies of good water, farms prosper, industries thrive, and cities grow. When water becomes scarce, farms may be abandoned, industries move away, and cities decline. Water is, indeed, one of Nature's greatest gifts to man.

Water, Water, Everywhere

Water occurs almost everywhere. We see it in oceans, in lakes, in small streams, in the water systems of our homes. It is part of our fruits and vegetables, of milk and eggs, of beef and fish. Soil, vegetation, even stones and coal, contain water.

WATER MAKES UP A LARGE PART OF THE EARTH'S SURFACE. Nearly three-quarters of the earth's surface is covered with water. In places the water is so deep that some of the world's highest mountains remain buried deep in the ocean, never reaching the surface. This is true of the Mid-Atlantic Ridge. If the earth's surface were flat and all the water in the oceans, lakes, and rivers were spread evenly over it, the whole earth would be covered to a depth of two miles.

Water occurs not only on the earth's surface, but also in its interior and in the atmosphere surrounding it. From within the earth, water flows forth as clear springs, or shoots out as geysers. In the atmosphere, it may be visible or in the form of dew, mist, rain, sleet, or snow.

The water on the earth's surface and in its atmosphere makes our planet a more comfortable place in which to live. The presence of large bodies of water moderates the temperature of cold places and cold seasons, also of hot places and hot seasons.

PUPIL INVESTIGATIONS.

1. Examine a map of your province and estimate the proportion of its surface covered with water.
2. Mark a large map of Canada into one-inch squares. Count the squares that are all or more than half water, and those that are all or more than half land. What portion of Canada is covered with water?

WATER MAKES UP A LARGE PART OF PLANTS AND ANIMALS AND OF OUR FOOD.

EXPERIMENT 5-1. Find out whether plants contain water.

Squeeze some juice from a fruit and collect it in a test tube or an evaporating dish. Boil the juice and hold a cold vessel in the escaping steam. Do the drops that collected on the vessel taste like the fruit juice? No, they contain water only. Similar experiments show that turnips, carrots, and potatoes, and also the leaves and stems of plants, contain much water.

EXPERIMENT 5-2. Does meat contain water?

Heat some uncooked meat. Try to collect drops of liquid on a cool vessel held in the escaping steam. Taste the liquid. It is water.

EXPERIMENT 5-3. Do fruits contain water?

Weigh some slices of apple. Leave them in the sun or in a hot oven until they are dry. Weigh them again. What proportion of the apple was water?

All parts of plants and animals contain some water. On the average, about four-fifths of all plant substance is water. Juicy fruits and vegetables contain much more. Even dry seeds, grains, and bark always contain water. Without it, they would be dead. Beef is about 60 per cent water, and bacon, 22 per cent.

Water makes up about two-thirds of the weight of our bodies. Nine-tenths of the blood and more than three-quarters of the brain is water. Our bones, too, contain much water.

In addition to the water we drink (six or more glasses a day if we follow good advice), we take in large quantities as part of our food. Cabbage and milk are nearly 90 per cent water; apples, 80 per cent; eggs, more than 60 per cent. Even crystals of salt and sugar contain water.

PUPIL INVESTIGATION.

Find out the percentage of water in each of several foods; then summarize your findings in a table similar to the following:

Water Content of Foods

Milk and Milk Products	Fruits	Vegetables	Cereals and Bread	Meat, Fish, and Eggs
Whole milk 87%		Potatoes 78%		

WATER IS A PART OF THE AIR. When a teakettle boils dry, or a puddle disappears, or wet streets or clothes become dry, the water must go into the air. When a mist or drops of water collect on a cold window, on our glasses when we come inside on a cold day, or on cool water pipes in a cellar in summer, we know that this water must have come from the air. As we could not see it, it must have been there in an invisible form, as water vapour.

The water vapour in the atmosphere makes it better for breathing and helps to keep our skins softer and healthier. It also makes possible the rain and snow which serve us in so many ways.

Water Is Essential to Life and Civilization

ALL LIFE NEEDS WATER. The first life on the earth began in water, first plants, then animals. Ever since, plants and animals have depended upon water to live. Plants will wither and soon die without water. Animals will die of thirst if deprived of water and foods containing it. Man depends upon water and soil for his food and clothing, even for the heat and power that he derives from coal, for coal comes from ancient trees which depended upon water.

Plants Need Water. From early life plants depend upon water. Only those seeds that contain moisture are alive. To germinate and produce young plants, these seeds need more moisture. Growing plants, whether young or old, will wilt and die without it. Some plants must always live in water.

All green plants use water as an essential food. The minerals which roots take in from the soil must be dissolved in water before they can be absorbed. Then water transports the dissolved minerals through the stems to the leaves, and the manufactured plant foods from the leaves to all other parts of the plant for growth. In spring it is the water in the sap that carries stored food to the opening buds.

Large bodies of water help plants by moderating the climate. Many fruits will grow in British Columbia, near the Pacific Ocean, but not in the more extreme climates of the Prairie Provinces. The Niagara Peninsula has become Ontario's fruit belt because its climate is moderated by Lake Ontario.

Man and Other Animals Must Have Water. The bodies of animals are nourished by water or by food containing it. Water in soil feeds plants. Plants become the food of many animals. Some of the smaller animals fed by plants may, in turn, become the food of larger animals. So all animals, whether *vegetarian* (feeding upon plants) or *carnivorous* (feeding upon flesh), depend upon water for food.

The water in our bodies serves us in three special ways. First, water helps us use our food. As a part of saliva, and later as a part of the digestive juices in the stomach and intestines, it aids digestion. As the main part of the blood, it carries the digested food to all parts of the body. Second, water collects waste substances and takes them to the skin, the lungs, and the kidneys for removal. Third, water helps to keep our bodies cool in hot weather. When perspiration evaporates from the skin, it cools the body. The following experiments will help us to understand why this is true.

EXPERIMENT 5-4. How does the evaporation of water change temperature?

(a) Wet your finger. Blow on it. Does it feel warmer or cooler?

(b) Wet a cloth with warm water. Feel it after several minutes. Does it feel warmer or cooler than the surrounding objects?

(c) Wrap the bulb of one thermometer with a dry cloth and that of another with a moist cloth. Leave the two thermometers together. Read the temperatures of the two thermometers from time to time. Which thermometer shows that cooling has taken place?

In each experiment some water evaporated or went into the air. As the water changed from liquid to vapour, it used up some heat. It took this from the finger and the damp cloth, making them cooler. For the same reason, when perspiration evaporates from the skin, the water takes some heat from our bodies and makes us feel cooler.

Wildlife depends upon water to meet many special needs. For fish, beaver, muskrats, wild ducks, and wild geese, water provides a home, a means of travel and protection, and a source of food. Animals that always live under water take oxygen from it for breathing. When streams stop flowing in summer, leaving stagnant pools, wildlife suffers. In some places man has helped wildlife by building dams. These store water in spring, then let it out gradually to keep streams flowing in summer.

WATER IS NEEDED FOR DOMESTIC PURPOSES. In the home, water is essential in three main ways: it plays an important part in the preparation of our food; it contributes to cleanliness; it is used for cooling and air-conditioning.

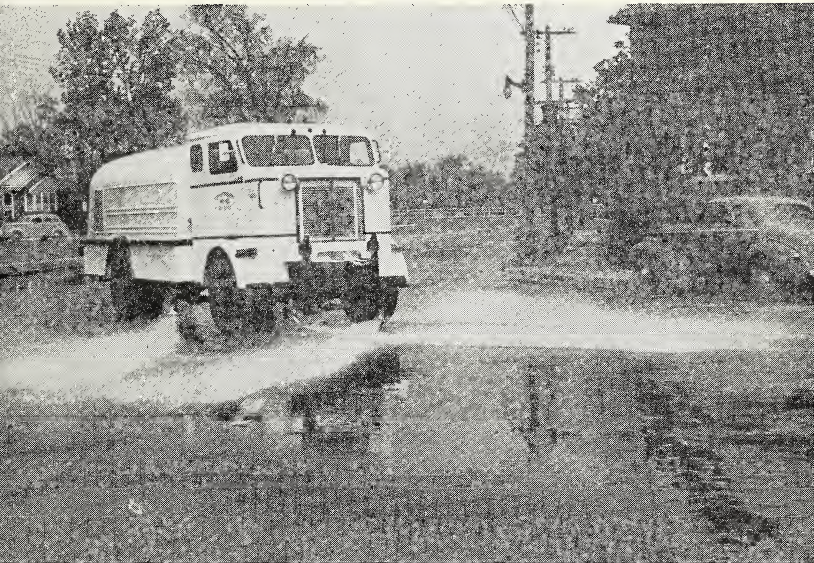
Water alone is a beverage and a food. It makes up the greatest part of fruit juices and fresh vegetables and a large part of other foods. Without it, we could neither preserve nor cook foods.

Water helps us more than any other substance to keep our bodies, our clothes, and our homes clean. Oil given off by the skin mixes with dirt, then collects on the skin and on clothing. Although water alone will not remove this oily mixture, it does help soap to loosen it, then carries them all away. In a similar manner, water, with the help of soap, enables us to keep our clothing and all parts of our homes clean. When we realize how important water is to personal and household cleanliness, it is easy to understand why better ways of living have resulted from the invention and use of modern water systems and household plumbing equipment.

New inventions to improve and increase the use of water and ice have made our homes more comfortable and healthier places in which to live. Water used in air-conditioning systems keeps the air sufficiently moist to be healthful. Ice, a form of water, is commonly used in refrigerators and in cold-storage systems to keep our food fresh and palatable.

WATER SERVES MANY COMMUNITY PURPOSES. Water helps to keep our communities, as well as our bodies and our

Fig. 5-2. A Street-flushing Tank Truck.
These spotless white tank trucks keep Toronto streets washed clean.



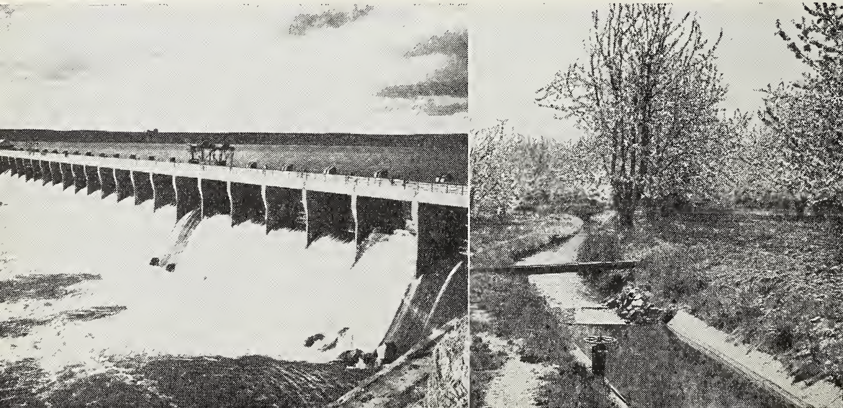
homes, clean, safe, and healthful. Rains, and water used by man to flush the streets (fig. 5-2), remove filth, making the community more healthful and attractive. The community water supply and the pressure under which it is distributed through the water mains to hydrants and homes determines how effectively the fire department can keep us free from the ravages of fire. With the help of modern conveniences in the kitchen, bathroom, and laundry, water is used to carry away sewage and other wastes from our homes, making both our homes and our communities safer and healthier places in which to live.

WATER IS ESSENTIAL TO AGRICULTURE. All kinds of crops must have water from the soil. To produce an ear of corn requires about a dozen pails of water. To produce a bushel of wheat requires about four thousand gallons or twenty tons of water. In one warm June day an acre of good pasture may absorb six tons of water. How important it is, therefore, that farmers use every method possible to conserve water in their fields.

The livestock, too, must have water. Streams, ponds, springs, and wells supply this the year round. In winter water

FIG. 5-3. WATER IS ESSENTIAL TO AGRICULTURE.

Left: The huge Bassano Dam, across the Bow River in Alberta, stores enough water from mountain streams to change many thousands of acres of land from dry wastes to productive farms by irrigation. *Right:* An irrigation ditch distributing water through a cherry orchard.



may be piped to the livestock in the stables. A good water supply is characteristic of a good farm. The best farmers take every precaution to see that the supply of water for stock is kept plentiful and pure.

WATER PROVIDES BEAUTY, PLEASURE, AND RECREATION. To enjoy ourselves and to obtain recreation, whether from day to day at home or during a holiday period, we all like to be near water.

In our home communities water makes possible swimming, boating, and fishing in summer, and skating and skiing in winter. We make wading and swimming pools, knowing that they will provide recreation, build good health, and help to develop habits of cleanliness.

Lakes and rivers provide beauty and healthful recreation. Beside these we build our cottages and summer cabins. In them we swim, fish, or go boating. In wooded areas dotted with lakes, still conserved for wildlife, hunters find their best autumn sport. Because streams, and the fish and wildlife they make possible, are so valuable for health and recreation, our governments put forth much effort and money to re-stock the streams with fish and to set aside preserves for birds, deer, and other wildlife. All good citizens, old and young, do all they can to conserve waterways and the wildlife in them.

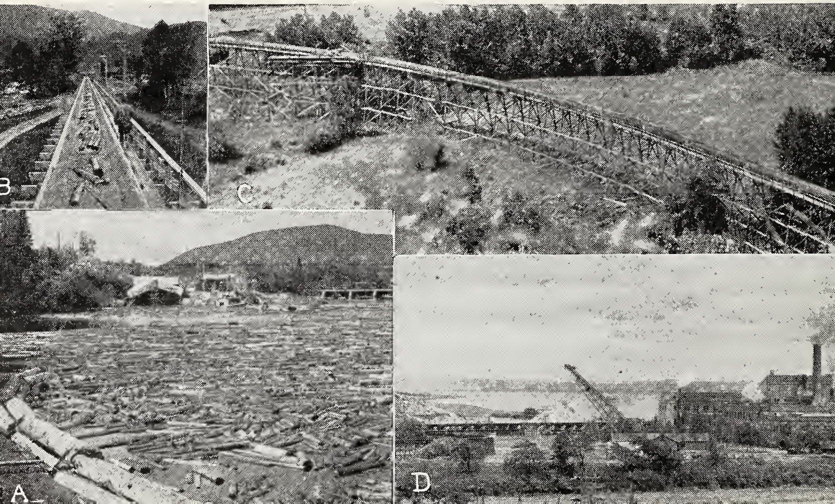
FIG. 5-4. WATER PROVIDES FOR MANY TYPES OF RECREATION.

WATER IS NEEDED FOR INDUSTRIAL PURPOSES. From early times man has used water as a source of power. Water turned the mill wheels of the pioneers, enabling them to saw their logs into lumber and grind their grain into flour. Our forefathers had to use this power beside the stream. Since then, we have learned how to change water power into electrical power and how to take this to wherever we want it to work for us — to operate machinery in our factories, to drive our street-cars and electric railways, and to light our homes, our schools, and our offices. This is just one of the ways in which a knowledge of science has helped us to improve our ways of living.

The use of electricity in so many ways in modern living makes the water in Canada's swift streams and waterfalls much more valuable now than ever before. Water power is one of our greatest natural resources. Although new dams are being built along such rivers as the Ottawa and the St. Lawrence

Fig. 5-5. Water Is Important in the Pulp-and-Paper Industry.

A. Ste. Anne River at Seven Falls, Quebec: the log pond, the flume take-off (under the canvas cover), the crest of the power dam, and the forests in the background — all dependent upon water. B. The flume through which water carries the logs a distance of nearly nine miles, down 1,000 feet. C. The flume supported on high trestles through the lowlands. D. The flume approaching the newsprint paper mill of St. Ann Paper Company, Limited, at Beaupré, Quebec, on the St. Lawrence River.



to produce artificial waterfalls, we have not yet developed more than one-quarter of the water power that our streams are capable of providing for us. When we have harnessed all the power of the mighty St. Lawrence River, perhaps we shall have enough electricity to drive our trains and to heat many of our homes.

Canada's great pulp and paper industry depends in large measure upon her water resources. Water is necessary for the growth of the trees. It transports the pulp-wood to the pulp mills. The water used to manufacture a ton of paper would fill an average classroom. Ninety-five per cent of the power used by the pulp and paper industry in Canada is electricity, and this is produced by water. In these ways water has helped Canada to develop the greatest pulp and paper industry in the world, and to make this industry the leading manufacturing industry in our own country.

Water works for us in many other ways. As steam, it drives our trains and boats — even the great ocean liner, the Queen Elizabeth. It is essential in nearly every industry. A ton of water is used in the manufacture of the woollen cloth for a man's suit. A steel mill would close as soon for lack of water as for lack of coal. Water is essential in many branches of the mining industry. Circulating in our radiators, it carries heat from the furnace to our rooms. It cools the engines in our cars. The wastes of many of our industries are taken away by water, too often contaminating our streams.

WATER IS A MEANS OF TRAVEL AND TRANSPORTATION. Water provided the early explorers with routes for travel, determined where the first settlements in Canada should be established, and has been a highway for the transportation of goods ever since. Sometimes water has been a barrier between nations; at other times it has helped to bring them together through communication and trade. History shows that countries separated by bodies of water are less likely to make war on each other than those with a man-made boundary line.

Water as a Map-maker. Most of the great discoveries and explorations recorded in history were made possible by water. Ocean voyages from Western Europe took explorers to Africa and India, around Australia, to America, and even around the world. The great rivers of North America, the St. Lawrence, the Ottawa, the Saskatchewan, and the Mississippi, led to the discovery, exploration, and settlement of the main areas in this continent. Waterways became boundaries between countries and provinces.

Water has determined the location of new settlements and the extent of their growth. The first settlement on Montreal Island was started there because the island was located where the Ottawa River emptied into the St. Lawrence River. The settlement grew to become Canada's largest city because this was the farthest inland that large ocean-going vessels could travel. Vancouver, Halifax, and St. John owe much of their growth to ocean traffic. Fort William, Port Arthur, Toronto, and many smaller lake ports have become important largely because they are situated on the Great Lakes waterways.

Water as a Highway. Throughout time man has used waterways as a means of travel and to transport goods. He could do so because his ships would float in water.

EXPERIMENT 5-5. Why do ships float?

(a) Find out which of these will float in water, and which will sink: wood, leaves, rocks, straw, iron. Do those that sink do so equally fast?

(b) Use a spring balance to weigh a block of wood, first in air, then resting partly in water. How does the water affect the weight of the wood? Why? Repeat the experiment, using a stone or a piece of iron. What effect did the water have on the weight of the piece of iron? See fig. 5-6.

The first of these two experiments shows that water holds up any object that weighs less than a volume of water equal to the volume of the object.

The second shows that even if the submerged object is heavier than an equal volume of water, the water pushes upwards on it, but not enough to make it float.

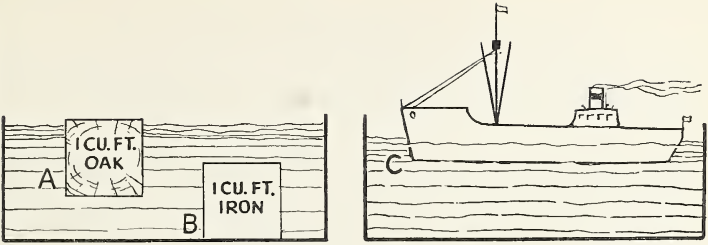


FIG. 5-6. WHY SHIPS FLOAT.

A. The oak floats because it is lighter than an equal volume of water.
B. The iron sinks because it is heavier than an equal volume of water.
C. The boat floats because it and its load are lighter than a volume of water equal to the volume of the boat.

(c) Place these in a pan of water: a piece of glass and a corked, empty bottle; a piece of china and a china cup; the top removed from a tin can and the empty tin can itself. Why do the vessels float while the materials of which they are made sink? The pieces of glass, china, and metal or heavier than an equal volume of water. Therefore, they sink. The vessels, including the air in them, are lighter than an equal volume of water. Therefore, they float. Place some pebbles in the empty tin can or cup. The cup or tin can rides lower, but it still floats. The container with its contents is still lighter than an equal volume of water.

A boat is somewhat like the empty cup or the tin can. As cargo is loaded, the boat merely settles lower in the water. It will not sink until the total weight of the boat and its cargo is greater than the weight of an equal volume of water.

Transportation by ocean, river, lake, and canal is cheaper than by railway or truck. The cost of developing new water routes is much less than the cost of building new highways and railways. After they are in service, the cost of maintaining canals and keeping water routes dredged is much less than the cost of keeping highways and railways in good repair. It is cheaper to transport wheat and flour from the Canadian West to Montreal through the Great Lakes, and to take manufactured products from the industrial centres of the East to the agricultural regions of the West by the same route, than it is to transport either of these by truck or rail.

Exercises

1. Make a table to compare the uses of water today with the uses of water fifty years ago. Select headings from this chapter.

2. Make an outline map of Canada, showing the main waterways. Insert, in as many places as you can, the names of the explorers who travelled along these routes. Indicate such obstacles to travel as falls and rapids, modern dams or power plants, and places that have become too shallow for water travel in recent years.

3. Make a list of all the water resources, past and present, in your community. Find out and state how their usefulness has been increased, decreased, or destroyed by man.

4. Explain how water transportation helped pioneer settlers.

5. State three reasons why transportation by water is cheaper than by truck, or aeroplane.

6. Mark on your outline map of Canada the names of cities that grew from settlements favoured by the presence of water. In brackets after each name, indicate whether development of the centre was caused by the presence of a good natural harbour, elevators, ship building, or some other similar factor.

7. Interview the managers of industrial plants in your community. Obtain answers to these and other questions; then make a report to your class:

(a) For what manufacturing processes is water used?

(b) How many gallons of water are used per day? Per unit measurement of each kind of product (e.g. yard of cloth)?

(c) From what source is the water obtained?

(d) What are the requirements with respect to purity of water used?

(e) Is water used to dispose of waste products? How?

8. Copy the following table in your notebook and fill in the spaces as accurately and completely as you can. Leave space for three or four lines of writing after each heading.

Water in Daily Living in Our Community

	Local Sources	Uses Made of It
Water Used in Homes		
Water Used by Farmers		
Water Used for Recreation		
Water Used for Industries		
Water Used for Travel and Transportation		

Test Questions

1. How does water help plants to obtain, make, and use their food?
2. State five ways in which animals depend upon water.
3. In what ways does water help a farmer? A hunter? A bricklayer? A mason?
4. Name three industries which use large quantities of water, and tell how each uses it.
5. In what ways does water serve an urban community?
6. State two ways in which water is a map maker, and two in which it serves as a highway.

◆

16 mm. Sound Films

Arteries of Life (SG-39)
Ontario Visual Education Branch.

What Makes Things Float? (with teacher's guide)
Ryerson Film Service, Toronto.

Film Strips

Welland Ship Canal
National Film Board, Ottawa.

Water

Why Things Float

Nothing Can Live without Water (colour)
Ryerson Film Service, Toronto.

Harnessing the Rivers
Canadian Film Institute, Ottawa.

6

THE INS AND OUTS OF WATER

WATER, like a tourist, is always going from place to place. Falling as rain, it goes into the roots of plants, then out of the plants through their leaves; into the soil, then out of it in springs or wells; into streams, then down their courses and out to lakes and oceans. From pool and ocean alike water goes back into the air and becomes rain once more, ready to set out on its travels again.

During its "ins and outs" water occurs in three forms, called *states:* namely, *liquid, solid,* and *gas.* Usually we think of liquid water as just plain water in wells, rivers, and lakes, or as beads of perspiration on our brows. Strange as it may seem, all clouds, fog, and mist are made up of liquid water in very fine particles. As a solid, water occurs as ice, frost, snow, and hail. As a gas, called *water vapour,* water is in the atmosphere, in the air we breathe out, and in the exhaust gases from an automobile. In its gaseous form, water is always invisible.

Water as a Liquid, a Solid, and a Gas

Some simple experiments will help us to understand the three states of water, and how it changes from one state to another. While performing and talking about these experiments, we will learn the language scientists use to describe the changes in the three states of water.

EXPERIMENT 6-1. Changing water from solid to liquid.

At home or at school, place some pieces of ice in a dish in a warm room. Leave a thermometer with its bulb in the bottom of the dish among the pieces. What happens to the ice? What temperature is indicated by the thermometer? Does the temperature of the mixture of ice and water change while the ice is melting?

EXPERIMENT 6-2. Changing water from liquid to solid.

Place the bulb of a thermometer in a dish of water, and put the dish in the freezing unit of a refrigerator. As the water *freezes,* read the temperature from time to time. What is the temperature? Does it change while there is still both water and ice in the dish?

The changing of water from solid to liquid is called *melting,* and from liquid to solid, *freezing.* A mixture of ice and water at 32°F. (thirty-two degrees Fahrenheit) remains at this temperature whether the ice is melting or the water freezing, so long as both ice and water are present. This temperature is called the *freezing point* of water or the *melting point* of ice.

EXPERIMENT 6-3. Changing water from liquid to gas (water vapour) and from gas to liquid.

Boil some water in a teakettle. Watch for a visible mist a little way out from the end of the spout. Hold a cold dish in this mist. What forms on the dish? Where did the water come from? Dry and cool the dish. Now hold it between the mist and the spout, in the place where you cannot see any mist. What forms on the dish now? Where did the water come from this time?

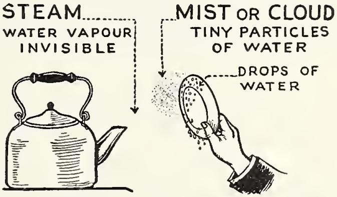


FIG. 6-1. WATER AS A LIQUID AND A GAS.

Heat causes the water to evaporate and form invisible steam (water vapour); cooling causes the water vapour to condense to form a cloud of tiny water drops. What finally happens to the drops of liquid in the cloud?

The visible mist in front of the kettle spout was really a *cloud.* It was visible because it was made up of tiny drops of liquid water. They joined to form the larger drops on the dish. The water seen in the cloud must have come from the spout. Why could we not see it on its way out?

Drops of water collected on the cool, dry dish when we held it between the cloud and the spout of the kettle. These formed from invisible water vapour on its way out from the spout to the cloud. Because this water vapour was so very hot, we called it *steam*. The dish cooled some of the steam enough to make it change back to liquid water. When the dish was not held there, the steam was cooled a little farther out by the cooler air and formed the tiny drops of liquid water in the mist or cloud.

When water vapour or steam changes to a liquid state, we say it *condenses*. The change is called *condensation*.

Air always contains some water vapour. When it contains all the water vapour it can hold at that temperature, we say the air is *saturated*. The warmer the air is, the more water vapour it can contain before it is saturated. Therefore, when air is cooled enough, it becomes saturated. If cooled more, some of the water vapour in it must condense to form liquid water as a cloud or a mist in the atmosphere, or as drops of water on cool objects. When much hot water escapes from a tap in a bathroom or kitchen, the air soon becomes saturated with water vapour. Then some of this condenses to form a mist and drops of water on the walls.

The cloud in front of the kettle spout disappeared again a little farther out. The particles of liquid water changed back to water vapour again, invisibly scattered through the air in the room. When liquid water changes to water vapour, as it did in the teakettle, and later in the surrounding air, we say it *evaporates*, and we call the change *evaporation*. Water evaporates rapidly when it boils, and more slowly at lower temperatures. Pure water, at sea level, boils at a temperature of 212°F. This is called the *boiling point* of water.

WATER AS A LIQUID IN NATURE. Liquid water occurs in streams and wells, in rain and dew, in clouds, fog, and mist.

We see it in our breath, in the exhaust from an automobile, and in smoke from chimneys on a cool day.

Clouds, fog, and mist are formed when the cooling of the air causes some water vapour to condense and form tiny drops of liquid. These are so light that they float in the air; they are so numerous and closely packed together that they are visible and wet our clothes. When high in the air, these tiny drops make up a cloud; when they are close to earth, they form a mist or fog.

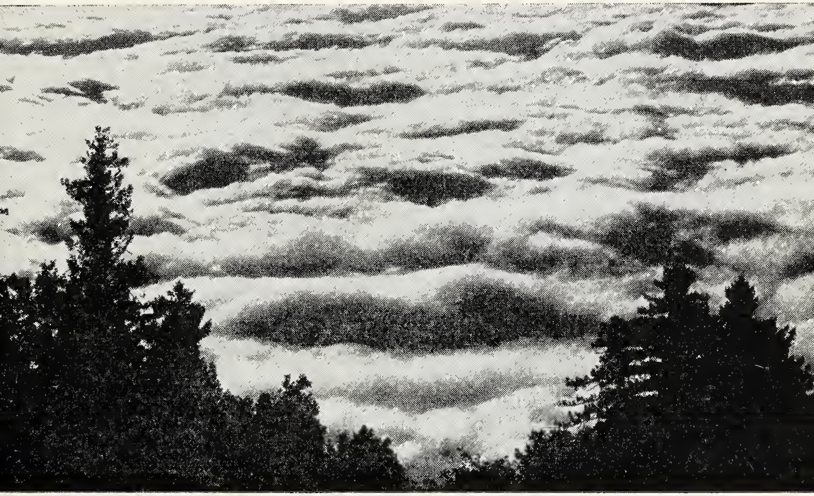


Fig. 6-2. A Fog as Seen from Above.
From an aeroplane such a dense fog looks like a wide layer of cotton batting. It seems hard to believe that it consists entirely of millions of tiny drops of water.

Most clouds end by becoming rain. The droplets of water gradually grow bigger and bigger, either by having more water condensed on them, or by combining with each other. When they become too big and too heavy to float in the air, the droplets fall to earth as raindrops.

Dew consists of drops of water formed on grass blades and on other objects at night. After sunset the grass blades become

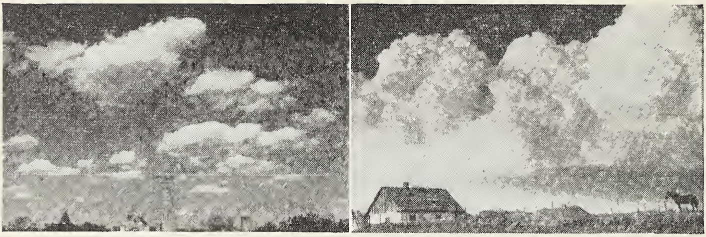


FIG. 6-3. THESE CLOUDS HAVE DIFFERENT FUTURES.
A, scattered cumulus clouds of fine weather; B, clouds that foretell an approaching storm, perhaps a hail storm, in Western Canada.

cooler and chill the air around them. When the air has cooled enough, it becomes saturated with water vapour. Then some of the vapour must condense to form a liquid. This liquid collects on the grass as dew drops.

EXPERIMENT 6-4. To show how and why dew forms.

> Place very cold water or a mixture of ice and water in a dry tumbler or a metal cup. Leave the container in a warm place. What formed on the outside of the vessel? Could the water have come through the vessel? Where did it come from? Why did the moisture form first as a dull mist, later as drops of water?

The water that collected on the container must have been present in an invisible form in the air around it. When made cold by the water, the vessel cooled the air close to it so much that the air could not continue to hold all the water vapour in it. Some of the water vapour condensed on the cold surface of the container. The first tiny droplets made up the mist. As these combined, or grew, they formed water drops, called dew. Dew forms on cold grass blades for the same reason and in the same manner.

Several factors determine the amount of dew formed. The more water vapour there is in the air, and the cooler the objects on the earth have become during the night, the more likely is heavy dew to form. Clouds and trees keep grass and other objects on the earth from losing as much heat at night as they would under clear skies. Therefore, the grass does not cool the surrounding air enough to cause much dew to form. Winds keep the air moving and so well mixed that none of it remains close to the cool grass long enough to cool and form dew.

WATER AS A SOLID IN NATURE. Water in the solid state occurs as ice, sleet, frost, snow, and hail. Each of these is formed under its own special conditions.

Ice. As soon as the water at the surface in a lake or stream cools below freezing point, it freezes, forming a layer of ice over the body of water. Sleet forms when rain, falling alone or mixed with snow and particles of ice, freezes on cold roofs, trees, and pavements.

EXPERIMENT 6-5. Observe ice forming on water.

Partly fill a shallow dish with ice-cold water. Cover this dish with glass. Place it in a larger vessel and surround it with snow or ice with which some salt has been mixed to make it colder and to increase its cooling powers. Cover the entire apparatus with layers of newspapers. From time to time uncover the glass and observe the needle-like crystals of ice forming, then interlacing until they form a continuous layer of ice.

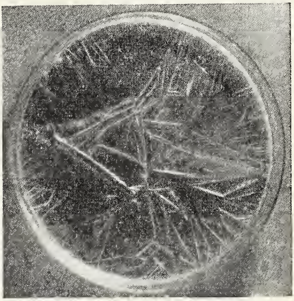


FIG. 6-4. ICE FORMING ON WATER.

EXPERIMENT 6-6. Does the freezing of water cause any change in its volume?

Fill a wide-mouthed bottle with water, even with the top. Place it where it will freeze. Is the ice formed even with the top? Which seems to need more space, the water or the ice?
Repeat the experiment, using a small bottle with a screw top. Why did the bottle break?

Ice requires one-eleventh more space than the water from which it forms. This fact shows that water expands during freezing. This expansion exerts great pressure, strong enough to burst water pipes and automobile radiators, causing much inconvenience and financial loss. To protect radiators of automobiles in winter, we fill them with anti-freeze, a substance which will not freeze at ordinary winter temperatures. Water freezing in a crevice in a rock often splits the rock. When water in the ground freezes in winter, it frequently lifts and breaks sidewalks. To prevent damage to our homes by the pressure of expanding water in the soil, we make sure that the foundation is deep enough that the soil beneath it cannot freeze and expand.

Why does ice float on water? A gallon of water, weighing ten pounds, produces about one and one-eleventh gallons of ice. A gallon of ice, therefore, weighs only a little more than nine pounds. Hence, ice floats in water with about nine-tenths of its volume under water. Because only about one-tenth of an iceberg is visible above water, the captain of a ship may fail to see it in time to avoid a serious collision.

EXPERIMENT 6-7. Which requires the lower temperature to freeze, ordinary water or a water solution?

> Place a dish of ordinary water and one containing a salt solution in the freezing unit of a refrigerator. Which freezes first? Use a thermometer to find out how cold the salt solution becomes before it begins to freeze.

Sea water contains salt in solution. Therefore, it does not freeze as soon as the water in lakes and ponds. The sap in plants is also a solution. For this reason, garden plants often survive some frost without being killed by freezing.

Frost. The cooler the atmosphere becomes, the less water vapour it can hold. When air cools sufficiently, it must give up some of the vapour in it. Usually this causes dew, fog, mist, clouds, or rain. If the temperature is below freezing point, the invisible water vapour in the atmosphere changes directly to tiny crystals of ice. These crystals often combine to form

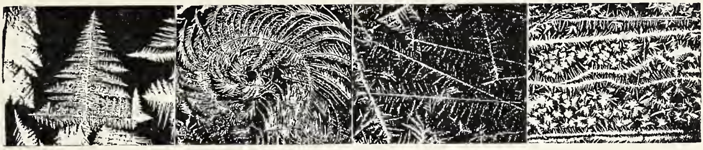


FIG. 6-5. FROST FORMATIONS ON WINDOW PANES.
What beautiful patterns the tiny ice crystals can form!

beautiful lacy patterns, sometimes resembling trees or ferns, on cold objects such as windows in winter and grass or fences on autumn nights.

Snow. Snow is produced from water vapour in the atmosphere in much the same way as frost is formed. When the temperature is below 32°F., any water vapour condensed in the atmosphere produces tiny ice crystals. A large number of these in a small area will form a cloud, just as water droplets do. As the crystals fall, they cool the lower atmosphere. This cooling causes some of the moisture in the atmosphere closer to the earth to change to ice crystals, too. As these attach themselves to other falling crystals, they help form objects of beautiful shapes, called snowflakes.

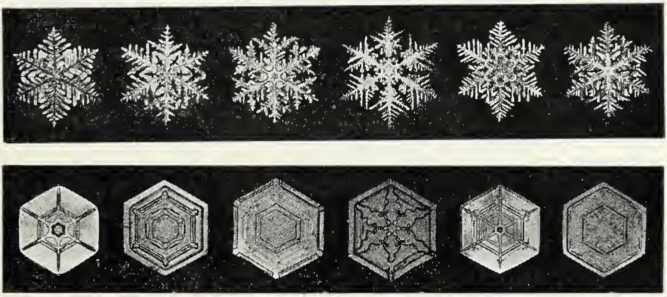


FIG. 6-6. SOME FORMS OF SNOW-FLAKES.
When the temperature is near freezing point, the flakes are usually large and feathery; in very cold weather, they are smaller and less feathery. All snow-flakes are six-sided and six-pointed.

Hail. A hailstone is made up of several layers of ice and snow. It begins as an ice crystal thousands of feet up in the air. As the hailstone falls through water droplets, it becomes wet. Occasionally its journey to earth is interrupted by the upward push of an air current. Each time this happens, the moisture on the surface of the hailstone freezes to ice. As the hailstone falls again, a layer of snow crystals condenses on it. Before it reaches the earth, it has several layers of both snow and ice.

Some Values of Snow and Ice. Both snow and ice help man to travel and to transport heavy loads by dog sled and sleigh. Ice enables the lumberman to haul logs onto lakes ready for the water to float them downstream in spring. Our toboggans and skis glide freely over snow, and our skates over ice.

Though the temperature of snow is below freezing point, it helps to protect man and other animals, also plants, from extreme cold. Eskimos remain comfortable in their igloos of snow. Some wild animals make their homes or seek temporary shelter beneath snow or ice. A covering of snow protects plants in winter because it prevents frost from going as deep or becoming as severe as it would be if there were no blanket of snow. So long as the snow covers winter wheat, clover, and garden plants in spring, it keeps them from being injured by the alternate freezing and thawing of the ground around them.

FIG. 6-7. SNOW IS BEAUTIFUL AND USEFUL. A layer of soft snow protects the plants beneath it from sudden changes in temperature.

When snow melts in

spring, it gives water to the soil. This is received later by crops, wells, and streams.

Snow and ice have their disadvantages too. Both hinder traffic on our streets and highways; both are costly to remove. Sleet makes air travel hazardous and weighs down or destroys telegraph and telephone wires, also trees. Ice in streams hinders navigation and, in spring floods, may cause costly damage. Frequently the rapid melting of snow in spring swells our streams and causes disastrous floods.

WATER AS A GAS. When water exists as a gas, we call it water vapour. Experiment 6-4 showed us that the atmosphere contains some water vapour, and that this water vapour may condense on cool objects to form dew. Review this experiment before reading further.

Although we cannot see it, water vapour is always present in the atmosphere. The amount present varies greatly from time to time and from place to place. Air that contains much water vapour is described as *humid.* Then we say the *humidity is high.* When the air contains little water vapour, we say the *humidity is low.*

Sources of Water Vapour in the Air. The water vapour in the atmosphere comes from many sources, such as drying clothes, wet soil and pavements, and all kinds of streams and bodies of water. It comes, too, from the leaves of plants, from the breath of animals, and from burning fuels.

Even ice gives water vapour to the air. In zero weather wet clothes on the clothes-line become stiff as the water in them freezes to ice. Later they become soft because the ice changes directly to water vapour in the air, leaving them dry. Can you think of other examples of ice or snow changing to water vapour?

Evaporation. Liquid water changes to water vapour by evaporation. Some experiments will show us what conditions favour evaporation.

EXPERIMENT 6-8. What conditions favour evaporation?

> Put equal amounts of cold water in each of six similar saucers, A, B, C, D, E, and F. Place A on a hot radiator and B in a cooler place nearby; C in the sun and D in the shade in the same room; E in a windy place or in front of a fan and F in still air at the same temperature. Record the time it takes the water in each to evaporate. Which condition hastens evaporation, heat or cold? Sun or shade? Wind or calm?

These experiments show that evaporation is hastened by warmth, sunshine, and moving air. Because we know that wet clothes dry more quickly in a dry room than in a damp basement, we may conclude that dry air favours evaporation.

Some Values of Water Vapour. Water vapour, though never seen, is always working for us. In the atmosphere, it makes the air we breathe more healthful, and forms the rain upon which our crops and streams depend. As steam, it drives many of our engines and heats our public buildings. As steam, too, we use it to sterilize instruments and utensils which otherwise might carry to us the germs of infectious diseases.

CHARACTERISTICS OF SOLIDS, LIQUIDS, AND GASES. A block of ice, and other solid objects such as a brick, a piece of wood, or a potato, can be handled and yet retain the same shape. They are not easily changed in size unless they are heated.

Water, gasoline, and milk, all of which are liquids, fill some of the space in a container, and may be poured from vessel to vessel, changing easily in shape. They always retain about the same volume.

Because air fills a rugby ball or a tire, we know it requires space. The fact that we can force it from a bicycle pump into the tire shows that it takes the shape of whatever vessel contains it. By holding the finger over the end of the pump hose and pressing down on the handle, we learn that air can be changed in volume quite easily by pressure. Steam escaping from a teakettle shows that it has the same characteristics as air. So have all gases.

The table below summarizes the facts we have just learned.

Characteristics of Solids, Liquids, and Gases

Kinds of Substances		Characteristics
Solids	brick, ice, pencil, stone	occupy space; volume not easily changed; shape not easily changed
Liquids	water, gasoline	occupy space; volume not easily changed; shape easily changed to that of the container
Gases	air, water vapour, oxygen	occupy space; volume easily changed by changing the pressure on them, or their tempperature, or both; shape easily changed to that of the container

THE WATER CYCLE. After a shower, the streets and grass are wet, and water lies in puddles. Soon all visible water has disappeared: it has evaporated, mixed with the air, and drifted away. Similarly, water is evaporating constantly from rivers, lakes, and seas. The warmer and drier the air, the more water vapour it can pick up. As air becomes more moist, it becomes lighter. Therefore, it rises. At higher levels, the air cools again, perhaps so much that it cannot hold all of the moisture in it. Then some of the water vapour condenses to form millions of tiny drops of water. These make up a cloud. The rain from it may fall far away from where the water was evaporated and the cloud formed.

When rain falls, it may either run off or soak into the soil. Water that runs off the soil will reach streams or evaporate on the way. Water that soaks in may either be taken in by

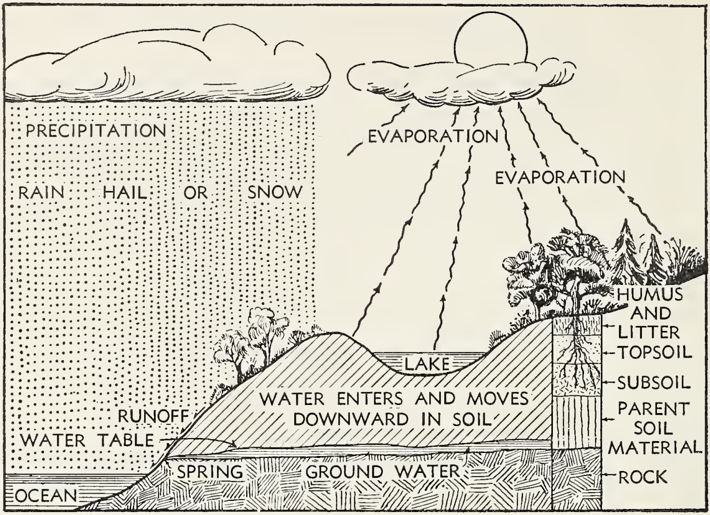


Fig. 6-8. The Water Cycle.

Water changes from liquid to vapour and from vapour to liquid, from sky to earth and from earth to sky, in an endless cycle.

the roots of plants or seep deeper into the soil. Water that enters plants may come out of their leaves again and become vapour in the air. Even the water that soaked deeper into the soil may come to the surface elsewhere in a spring or well, and perhaps evaporate again. Water goes through this series of changes over and over again — liquid water, evaporation, water vapour, condensation, clouds, rain, streams, evaporation again. This continuous series of changes of water from liquid to vapour, then back again to liquid, is called the *water cycle.*

Think These Through

1. Why do kitchen windows steam up more than those in other rooms?

2. Why do the walls, mirrors, and windows become moist in a bathroom when someone takes a hot bath in cold weather?

3. Why do the windows of an automobile carrying several people become misty or frosted on a cold day when the windows are kept closed? Why does opening a window or operating an air-conditioning system in the car prevent this?
4. How do clouds differ from fog? How are they similar?
5. How are rain, fog, and dew similar in origin?

A Review Exercise

1. State as many uses of water as you can think of:
(a) as a solid (b) as a liquid (c) as a gas
2. Explain the formation of frost, snow, rain, and dew.
3. Make a diagram to show how you think the water cycle should be illustrated.

Water Makes Some Things Disappear

Water makes it possible for us to use sugar and salt to flavour our food. It enables plants to take in minerals and fertilizers with water from the soil. Because of its action on soap and dirt, we use water to wash our hands and our clothes. We shall now see how this ability of water to dissolve things helps to make it so important to us.

WATER DISSOLVES SOME SOLIDS.

EXPERIMENT 6-9. Dissolve some sugar in water.

Add half a teaspoonful of sugar to a glass of water. Stir the mixture well. Does the sugar remain visible? Taste the liquid. Is there sugar in it? Filter some of the liquid through filter paper or a fine cloth. Taste it again. Did the sugar go through? Put some of this liquid in a shallow dish. Boil it till no water remains. Is there sugar in the dish?

Taste proves that the sugar, though invisible, was still in the water after it was filtered. We say the water dissolved the sugar, that is, changed it into such tiny particles that they were invisible and could even pass through filter paper. The water and the tiny dissolved particles of sugar made up a *solution.* Because sugar will dissolve in water, we say it is *soluble* in water. Because the water did the dissolving, we call it the *solvent.*

EXPERIMENT 6-10. How does the temperature of water affect the amount of a substance it can dissolve?

Put sugar in a tin can of water till no more will dissolve when stirred. Heat the solution. Then add more sugar until all possible is dissolved. Increase the temperature of the solution and add more sugar. How does the temperature affect the amount of sugar the water can dissolve? When a solution contains all it can of a dissolved substance at a given temperature, we say the solution is *saturated.*

EXPERIMENT 6-11. Do all substances dissolve in water with similar ease?

Place half a teaspoonful of each of these in separate tumblers: salt, sugar, sand, bluestone, chalk dust, baking soda. To each, add an equal amount of cold water at as nearly the same time as possible. Which substance is entirely dissolved first? Next? Which substances do not appear to dissolve at all?

Some substances, such as chalk and sand, will not dissolve in water. We say they are *insoluble.* Others dissolve very slowly or only in small amounts. Grinding a substance into a fine powder and stirring it well in water helps it to dissolve more rapidly.

EXPERIMENT 6-12. Does water dissolve any substances from soil?

Shake some soil with water. Let the mixture settle for a few minutes. Pour the water through a filter paper. What collects on the paper? How did the filter paper change the water passing through it? Is the water now perfectly clear? If not, let it stand until no particles are visible in it.

Boil some of the clear water in a clean dish until all of it is evaporated. Is any solid material left in the dish?

The material on the filter paper consists of undissolved particles of soil and decaying vegetation. These are light enough to be carried off from a field in running water.

The material left in the dish consists of soluble minerals taken from the soil by the water. These minerals must have been dissolved, for no particles were visible in the filtered water. Water in the soil dissolves such minerals, also fertilizers, and carries them into the roots of plants. Water running over the soil or through it may also dissolve such soluble minerals and carry them away.

THE IMPORTANCE OF WATER AS A SOLVENT. Water is always ready to dissolve things and make them more useful to man. By dissolving some substances from rocks, water helps to form soil. Because water dissolves minerals and fertilizers in the soil, plants can take them in and use them to make their food. The plant materials grown from this food become our food.

In the cooking and preparation of our food, water is constantly dissolving such substances as sugar, salt, and baking powder. Our drinking water tastes better because of minerals dissolved in it. As part of our saliva and other digestive juices, it keeps on dissolving our food, making it ready to nourish all parts of our bodies. Then it carries away body wastes in solution.

Because water dissolves soap, and soapy water loosens or dissolves dirt, we can use water and soap to keep our bodies, our clothes, and our homes clean.

The dissolving power of water can make it harmful to man. When water runs off fertile fields in spring or during heavy rains, it carries with it some dissolved minerals. When water soaks down through sandy soils, it carries soluble plant foods out of reach of the roots of plants. We call the latter process *leaching*.

WATER DISSOLVES AIR AND OTHER GASES.

EXPERIMENT 6-13. Does water contain dissolved air?

Fill a tumbler with cold water. Leave it in a warm room. Watch bubbles form on the inside of the glass. These contain air. This air could not have passed through the glass from the outside. From where must it have come? Why could we not see the air in the water before?

Repeat the experiment, using ginger ale. Where did the bubbles come from? Taste the liquid before and after the bubbles stop forming. The bubbles contain carbon dioxide, which was dissolved in the beverage to add to its flavour.

Water dissolves air, also carbon dioxide and oxygen separately when they are mixed through it. Cold water can hold more of these gases in solution than warm water can hold. Therefore, some of the dissolved gas comes out of solution as the water is warmed. Fish and other water animals breathe the oxygen dissolved in the water. In an aquarium containing fish, if plants are not grown to supply oxygen to the water, it is necessary to replace the water frequently with fresh water containing more dissolved oxygen.

Water tastes "flat" after being boiled. Boiling drives air out of solution, causing the change in taste.

WATER CAN BE PURIFIED BY DISTILLATION. Water from rain, streams, and wells is not pure. It always contains some dissolved gases and solids. To obtain pure water, we must separate these dissolved substances from the water. Gases in solution are driven out by heating. Solids in solution may be separated as in experiment 6-12. As the solution is boiled, the water changes to water vapour (steam) and passes off. Steam is pure water in vapour state. To change the steam to liquid, we force it into a cool place and collect the water formed as the steam condenses. This gives us pure water. The process of changing the water of a solution to water vapour, then condensing the vapour to form liquid water, is called *distillation*. *Distilled water* is pure water.

Hard and Soft Water

We often speak of water from rain or snow as soft water, and water from a well or spring as hard water. Soft water feels softer to the skin. Water from lakes and rivers may be soft like rain water, hard like well water, or between these in hardness. Some experiments will show us how soft and hard waters differ.

EXPERIMENT 6-14. How do soft water and hard water differ?

(a) Fill one wash basin with rain water and another with water from a well. Try to wash your hands in the hard water, using one teaspoonful of soap flakes. Repeat the experiment, using the rain water. For the two experiments, compare (1) the feel of the two kinds of water; (2) the ease with which dirt is washed from your hands; (3) the amount of lather formed.

(b) Make a soap solution by dissolving all the soap you can in a tumbler of warm water. Obtain several bottles or jars. Put half a cup of each of the following into separate jars: rain water, water from melted snow, tap or well water, water from a lake or river, and salt solution. While shaking the jar of rain water occasionally, add soap solution to it, a drop at a time from a medicine dropper, until a foam or suds remains on the surface. How many drops of soap solution were needed? Were any curd-like particles formed?

Repeat the experiment with each of the other bottles or jars. In each case, keep a record of the number of drops of soap solution needed to form a suds, also of the formation of curd-like particles.

Which uses the more soap to form a foam or suds, soft rain water or hard well water? In which is more curd formed?

The harder the water, the more soap it requires to form a suds, and the more curd is formed by the soap used up. Use this statement to arrange, in order of hardness, the different kinds of water you tested.

Hard water is also injurious. The curds produced by the wasted soap clog the pores of the skin and give the hair a dull appearance. They injure clothes by making the fabric more brittle, causing them to wear out more rapidly. In the kitchen, hard water toughens food while it is cooking.

Hard water boiled in a teakettle causes greyish-white scales. None of these are formed by soft water. The fact that the scales consist of mineral substances shows that hard water contains dissolved minerals. Boiling hard water helps to soften it by removing some of the minerals dissolved in it.

Water from a well or tap was once rain water. As it passed down through the soil and over rocks, it dissolved some minerals, usually calcium and magnesium. By the time the water had reached the well or spring, it contained enough mineral matter to be "hard".

Some kinds of hard water are softened by boiling; others, by chemicals. Washing soda or borax are commonly used in the home to soften wash water. You can plan an experiment, similar to experiment 6-14 (b), to test the effects of these chemicals on hard water. The washing soda and borax needed to soften hard water cost much less than the soap wasted without them. At the same time they keep the water from harming the hands and clothes.

Water softeners may be installed in the home water system. Chemicals in these remove the minerals from the water as it passes through them.

Important Facts To Remember about Water

1. Pure water has no taste, colour, or odour.

2. Pure water at sea level boils at 212°F. and freezes at 32°F.

3. Water expands about one-eleventh when it freezes.

4. Water occurs in three states: solid, liquid, and gas.

5. Water can be changed from one state to another by heating or cooling it. Heat causes evaporation; cold usually causes condensation.

6. Evaporation of water is hastened by heat, moving air, dryness of atmosphere, and increased surface exposure.

7. Water is always present in the atmosphere, either as invisible water vapour or as tiny particles of liquid, visible in fog, mist, and clouds.

8. Water dissolves many solids and gases. Heat increases the amount of a solid that can be dissolved in water, but cold increases the amount of a gas that can be dissolved in water.

9. Salt water and other solutions require a lower temperature than 32°F. to freeze.

Testing Exercises

1. State three ways in which hard water and soft water differ.
2. Tell how hard water wastes soap.
3. Mention two ways of softening hard water.

4. Name five ways in which we are helped in everyday life by water dissolving things.

5. Name some substances which are more useful to us because they do not dissolve easily in water.

6. Explain why radiators of cars sometimes burst in cold weather. Tell how anti-freeze prevents this damage.

7. Why can we not see the sugar a little while after we have scattered it over hot cereal? Why are salt in the sea and minerals in pond water invisible?

8. Explain what you understand by the terms: evaporation, condensation, distillation, water vapour, water cycle, dissolve, solution, solvent.

Things To Do

1. Visit a stream and notice the following: how the moving water is transporting soil, how the water has worn away rock, soil being deposited in new places, and stones which have been worn smooth and round by the action of the moving water. Take back to class a jar of muddy water from the stream. Let it stand until the sediment has settled to the bottom. Observe the amount of soil deposited from the water.

2. Write the story of a river. Tell of its source in high lands, its journey through cities, the living things in it, the unwise treatment it receives along the way, and the additional uses which could be made of it with proper treatment.

Explain This

If the air in your classroom is moist and its temperatures were suddenly changed to 34°F., you would be surrounded by a fog. Why? If the air were cooled to 26°F., you might see tiny snowflakes falling around you. Why?

◆

Read

Compton's Pictured Encyclopedia: "The Causes of Floods and How Men Fight Them", Vol. 5, pp. 143-146; "The History of a Cake of Soap", Vol. 13, pp. 211-215; and "Nature's Chief Tool and its Amazing Power", Vol. 15, pp. 60-64.

16 mm. Sound Films

The Clouds Above (SG-48)

What Makes Rain (SG-20)

Water Cycle (SG-27)
Ontario Visual Education Branch.

The Work of Ice

Properties of Water (black and white, also colour)
Associated Screen News Limited, Toronto.

Film Strips

Water and Its Work

All Matter Has Three Forms
Ryerson Film Service, Toronto.

7

WATER MUST BE CONSERVED

THE FIRST WHITE MEN who came to America found a land rich in natural resources. There were forests that seemed without limit, streams full of fish the year round, vast areas of grass-covered prairies, and a wealth of wildlife throughout the land. The pioneers thought of Canada as a land of plenty. They saw no need to conserve her forests and prairies, or to think of saving her soil and water.

The early settlers cut the trees for lumber and timber, or to clear land for their crops. They ploughed under the luxuriant grasses of the prairies to raise wheat. Little did they realize that the scarcity of forests and grass would cause rivers to stop flowing in summer, springs and wells to go dry, and running water to wash away fertile soil and produce devastating floods. While these changes, brought about by our forefathers, made our water supplies become less and less, other changes in our ways of living made our needs for water greater and greater. This chapter will show why we must conserve water more efficiently to meet our daily needs, and how we may co-operate with nature to make the water that falls as rain and snow more useful to us.

Introductory Pupil Investigations

1. Study the water resources of your community, then draw a map of the area to show its lakes, streams, dams, and water-power plants.

2. Examine books and magazines for information on water conservation, then make a list of a dozen or more headings under which the values of conserving water might be studied. Make notes and drawings and mount clippings under each heading as your study of water conservation continues.

Why Water Must Be Conserved

An enormous amount of water is needed every day to satisfy all our requirements. We need it to drink; to keep ourselves, our homes, and our communities clean; and to feed the plants from which we obtain our food and clothing. Let us not forget the water used to generate the electricity we use for light and heat and for power to manufacture useful goods. There need be little wonder at the fact that 700 gallons of water are put to use for each person every day. For these reasons we must conserve our water supplies.

TO INSURE ADEQUATE SUPPLIES FOR HOME AND COMMUNITY USE. The amount of water needed in our homes has been increased by the use of modern plumbing in kitchens, laundries, and bathrooms. Still more water is needed to water lawns and wash automobiles. Urban centres use more and more water for cleaning streets and for fire protection. The average city supplies about 150 gallons of water per person each day to meet these needs alone. In the country, wells and springs must meet increased demands.

TO PROVIDE ENOUGH WATER FOR CROPS AND LIVESTOCK. Farms depend upon water to grow crops and to raise livestock. Crops and livestock give us our food. As the years pass and the population continues to increase, we will need more food, therefore more crops, and more water. Many lands that were once considered too dry to grow crops are being irrigated. More and more acres will be irrigated, and for these more water will be needed.

Unfortunately, the supply of water on our farms is decreasing while the need for it is increasing. Often wells fail to give enough water to meet the requirements of people and stock. In summer time many streams from which livestock drink go dry. Frequently pastures and crops suffer from lack of water, producing less food for us. All these things happen because there is not enough water stored in the soil. We must, therefore, find ways of increasing and conserving water in the soil.

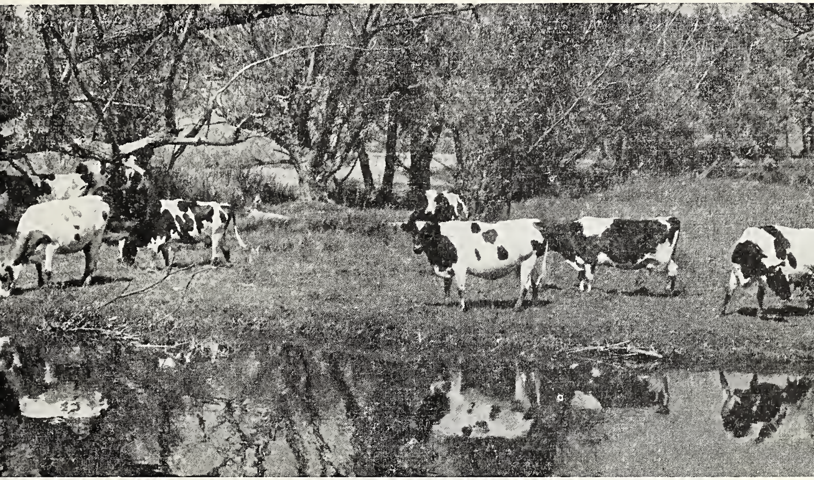


FIG 7-1. WATER IS ESSENTIAL FOR THIS DAIRY HERD.
The crystal-clear stream, the fresh green grass, and the shade-giving trees are all made possible by water.

TO SATISFY NEW AND INCREASED DEMANDS BY INDUSTRIES. The number and the size of manufacturing industries in Canada have increased greatly in recent years. Over a period of ten years, they have required fifty per cent more water from wells, rivers, and lakes. Huge quantities of water are used by the growing pulp and paper industry alone. Most industries use electricity for both power and light. To meet this need, our streams must provide more and more water power.

TO RESTORE STREAMS NOW DRIED UP. Many rivers and smaller streams which once flowed the year round are now dry, at least for a part of the summer. A survey of two areas near Toronto showed that eighty per cent of the original streams are now useless although many of them, at one time, provided enough water to operate a grist mill or a sawmill. We need these streams for fish and wildlife, for electric power, for domestic water supplies, and for recreation. We must make them flow again as they used to. We shall now find out how to do so.

Man and Nature Can Conserve Water

The water from raindrops and melting snow has an uncertain future. When the water reaches soil, some of it immediately evaporates into the air; some remains on the earth's surface in creeks, rivers, and lakes, as *surface water;* and the remainder soaks into the ground to become *ground water.* Most of the surface water runs off to lower levels, often doing much harm as it goes. The ground water remains in the soil where it feeds the roots of plants; or it passes through the soil and later becomes useful to us in wells, springs, or clear creeks and rivers.

FORESTS AND OTHER VEGETATION TRAP RAINDROPS WHERE THEY FALL. Forests help to keep water where it falls as rain. Raindrops falling into a forest are broken in their fall by the trees. Stopped by the leaves, the rain runs along the branches and twigs, or trickles from the leaves, gradually finding its way to the ground. The forest floor, with its mat of dead twigs, decaying leaves, and other plant remains, and its network of roots, takes in water easily. Beneath this loose litter, the layer of decayed vegetation (leaf mould) which gradually merges into more completely rotted plant remains, called *humus,* absorbs this water. Beneath the decaying plant remains is rich soil filled with more living and decaying plant roots, and such animals as earthworms and insect larvae. All these living things help to keep this deeper soil so open and crumbly that it, too, can hold large amounts of water. The forest floor is indeed a huge reservoir for the storage of water. The top two feet of forest soil can hold as much water as can be stored in a tank one foot deep and of the same area as the soil.

EXPERIMENT 7-1. How do leaf mould and mosses help forests to absorb and hold water?

> Half fill two large flower pots, or tin pails containing drainage holes, with garden soil. Over the soil in one, place two or three inches of fine leaf mould and pieces of moss from a wood. Support the containers over plates. Pour the same amount of water into each. Catch what comes through. Which let more water escape? Which held more water? What made the difference?

Forests trap the water from snow as they do the water from rain. They both delay and slow down the melting of snow in spring. Shaded by the trunks and branches of deciduous trees and the foliage of evergreens, snow takes from a week to a month longer to melt in a forest than it does on an exposed field. This gives the water from snow a longer time to soak into the soil. For this reason, the water from snow melting in the woods often soaks into the forest soil in seasons when it would run off the frozen ground of open fields.

FIG. 7-2. WHEAT BLADES STOP THE FALL OF RAINDROPS.

A covering of grass or other vegetation, like the trees in a forest, helps to trap raindrops and hold the water where it falls. Every blade of grass and every stalk and leaf of clover breaks the fall of rain and keeps it from packing the soil. On hillsides, the stems and leaves, like little dams, keep the water from starting to run away, and give it more time to soak into the soil.

PUPIL INVESTIGATIONS. **How are grass roots and the soil around them adapted to take in and hold moisture?**

(a) Dig into a grassy place. Examine the closely matted roots in the soil. To what depth do they grow? Notice how loose and mellow the soil is kept by the living and dead roots.

(b) After a rain, dig into grass-covered soil and bare soil near each other. In which soil did the water penetrate deeper? How did the grass and grass roots cause the difference? Which soil remains moist longer after the rain?

The mat of closely growing grass roots fills the soil to a depth of several inches. While they grow, the roots keep the soil loose; when they die, they add humus to it. For these reasons, the soil in a grassy place absorbs water more freely than bare soil, and holds more of it.

Things To Think About

1. Anything that helps to slow down the journey of raindrops and water to a stream helps to conserve water in the soil. These all assist: leaves and branches of trees, weeds and grass plants, stones and pebbles, fallen leaves and decayed vegetation, swamps and marshes, the roots of trees and of other plants.
2. To be most useful, rain should be checked by vegetation, allowed to soak slowly into the soil, and either be held there or passed down to the storage layer of underground water.

TRAPPED RAINDROPS BECOME USEFUL. The raindrops which serve us best are those that soak into the ground.

Ground Water and Water Table. When water from rain or snow has soaked into loose, cultivated soil, or into ground covered with vegetation, it first fills the fertile topsoil. Gradually it soaks deeper and deeper. Finally it comes to a layer of rock or clay through which it cannot pass. As more water comes down, it completely fills the soil, forming a reservoir of ground water for a distance above the rock. The top of this layer of ground water is called the *water table*. See fig. 6-8.

We see where the water table is when we dig a well or a post hole near a stream, for the water will fill these only to the level of the water table. In dry weather the water table lowers; in rainy seasons it rises higher and closer to the surface of the earth. This is why wells have more water in them at some times of the year than at others. When the water table is close to, or slightly above, the level of the soil, the water forms a marsh or swamp.

PUPIL INVESTIGATIONS.

Find out how deep the wells in your neighbourhood must be dug or drilled to reach water. Ask residents who have lived there for many years whether the wells dug 25 or more years ago had to be as deep. If the wells must be deeper today than previously, the water table must be lower.

The Importance of Ground Water. The ground water is the most valuable to man and other living things. Near the surface it becomes food for green plants; there, also, it dissolves minerals from the soil and helps the plants to absorb them. In dry weather ground water rises from lower levels and keeps plants growing. Some of the ground water from beneath the water table may find its way to the surface, perhaps on a hillside, as a spring. Springs feed streams throughout the summer, keeping rivers flowing the year round. The water of springs and of rivers near their source is usually so clear and sparkling that it serves well as drink for man and livestock. Elsewhere the ground water fills our wells to the level of the water table.

More Forests and Grass Are Needed To Conserve Water. In many places today, the water table is always lower than it was when the pioneers built their homes and dug their first wells. Frequently our crops lack water and our wells go dry because too little water soaks into the soil and becomes ground water. Man has caused this. When he cut the forests from the tops and slopes of hills, he destroyed the layer of dead leaves and other decayed plant materials which had, like a sponge, stored up the water from rain and melting snow. In place of these forests, man now has millions of acres of bare soil from which water runs rapidly away instead of soaking in to become ground water.

An interesting experiment showed how well forests and grass keep water from running off the land. A wood, a hay field, and a cultivated field were selected, all of the same area and of similar slope. The amounts of water that ran off these were accurately measured. So were the amounts of soil carried away by the water. The results are shown in fig. 7-3.

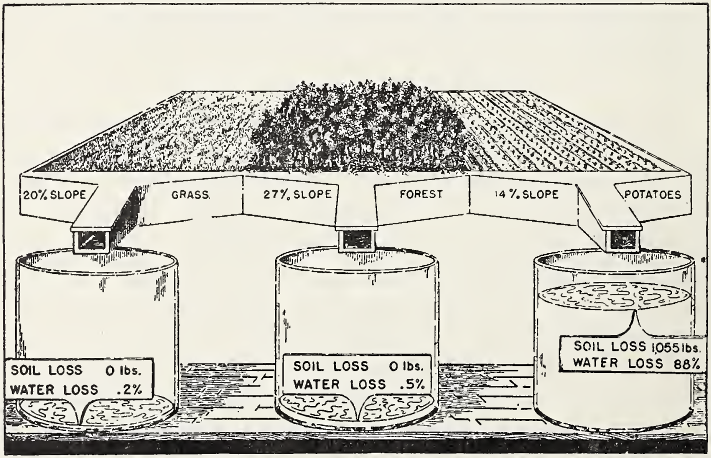


FIG. 7-3. FORESTS AND GRASS HOLD WATER AND SOIL.

These are the results of an actual experiment. The loss of water and of soil were measured during three weeks in which 9½ inches of rain fell. Compare the slopes of the three areas. From which slope would you expect the most water to run off? Compare the amounts of soil and of water lost by the three areas. Try to account for the differences.

More forests and grass lands will conserve more water. All hilltops and steep slopes not already covered with trees should be planted to forests. The more gradual slopes should be left in hay or pasture instead of being cultivated. Then most of the water from rain and snow will become ground water, useful later in soil, wells, and springs. Here are two proofs that this is true. In one district, springs that had been dry for fifty years began to flow again six years after the nearby hills were reforested. In another district, a good farmer bought several neighbouring farms where crops had been poor, floods frequent, and springs and wells dry in summer. By good methods of cultivation, and by keeping the slopes in grass, he caused so much of the rain to soak into the soil that his crops grew well and many new springs started to flow in a very few years.

LOST RAINDROPS ARE BOTH WASTED AND HARMFUL. Water that runs off the surface of the soil instead of soaking into it is no longer useful to us; it is lost, wasted. Run-off water is harmful, too, when it cuts gullies in our fields, carries away our fertile soil, or, as a flood, overflows the banks of streams and brings destruction to man and other living things, and to property.

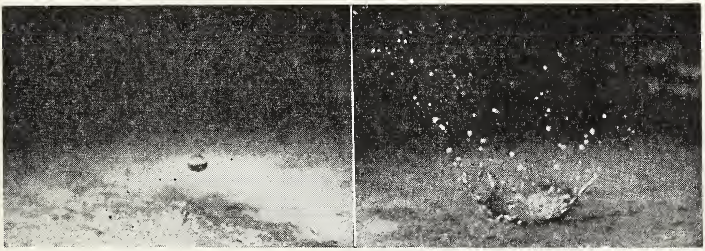


FIG. 7-4. THE SPLASH OF A RAINDROP LOOSENS THE SOIL.
Left: The water in this falling raindrop has collected some dust as it fell. It is no longer pure. *Right:* A raindrop striking the earth is like a miniature bomb. On bare soil it blasts soil particles loose. The soil particles, mixed with the water, make it more impure. This water, joined with that from many other raindrops, erodes the soil and, later, pollutes streams. Grass prevents this splash erosion, causes rain water to soak into the ground, and helps to keep streams pure.

Erosion Must Be Stopped. All too often we have seen water running off the land and wearing away soil as it goes. We call this destructive action of running water *erosion.*

Some Pupil Investigations

1. Explore the schoolyard during and immediately after a heavy fall of rain to see how falling raindrops and running water loosen and carry away soil. Compare the amounts of erosion on level and on sloping areas, also on grass-covered and on cultivated areas with the same slope.

2. After a heavy rain, dig into the soil on a slope (1) in a grassy place, (2) where the soil is cultivated, (3) on a tramped pathway. Compare the depths to which the water has soaked in.

Observations in four places, all having the same slope, showed that a heavy rain caused water to soak down 8½ inches in a wood, 6 inches in sod, 4 inches in a corn field, and 1½ inches in a bare field. The remainder of the water ran off.

Water is more likely to run off than to soak into soil where the surface is hard, vegetation is lacking, or the land is sloping. Naturally, a hard surface makes it harder for water to enter the soil. Therefore, more of it runs off, eroding the soil as it goes. Where there are no trees and no other plants growing close together, the raindrops fall hard upon the soil, pound its surface until it becomes a closely packed layer, and then run off because they cannot enter the soil through this layer. On a sloping surface gravity pulls the water downhill so fast that it has little time to soak in. The steeper the slope, the faster the water runs; the faster the water runs, the more soil it loosens and carries with it, and the more ditches and gullies it forms. See fig. 7-5.

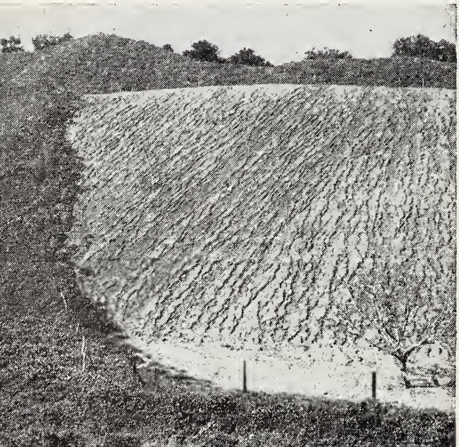


FIG. 7-5. GRASS PREVENTS SOIL EROSION.

Where the hillside was covered with grass, water soaked in; where the soil was bare and cultivated, much erosion took place. Notice the new soil deposited at the base of the hill.

Fortunately, we can take steps to reduce or prevent erosion. It is particularly important that we do this in autumn to prevent the rains of autumn and spring, and the water of melting snow, from carrying away valuable soil. Before man came, Nature prevented erosion by keeping the soil covered with forests and grass. We can copy Nature by planting more forests and leaving more pasture fields on steep slopes. In fall we can sow rye on cultivated hillsides to keep running water from carrying away soil in winter and spring.

Crop refuse, stubble, and manure on the surface of the land slows down run-off water and holds the soil in place. Hillsides should be left covered with stubble in fall, or cultivated in such a manner that crop refuse remains on top.

EXPERIMENT 7-2. How does cultivation across a slope help to conserve water and soil?

Arrange two wood or metal troughs, each about eight inches wide and four inches deep, as shown in fig. 7-6. Place about three inches of soil in each, press it firmly, then make ridges crosswise in one and lengthwise in the other as shown. Tilt the boxes to the same slope. Sprinkle equal amounts of water over the top of each until some water runs off. Catch the run-off water. Compare the amounts of water and of soil lost by the two troughs. Explain the difference.

When slopes are cultivated crosswise, rather than up and down, the ridges of soil serve as little dams and hold back the water, giving it more time to soak in. The rougher the surface is left, the more ridges and high spots there are to stop the downward flow of the water. Not only do these methods of cultivation help to prevent

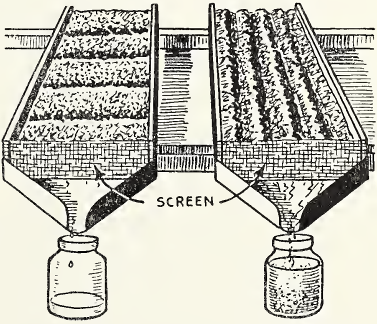


Fig. 7-6. Cross Cultivation Saves Water and Soil.

erosion; they cause more water to soak into the soil and become useful ground water.

In chapter 20 we shall learn about other ways in which farmers can conserve soil and water, especially on sloping land.

Floods Must Be Prevented. Floods are more common and more harmful today than they were at the time of the explorers or of the pioneers. When the land was covered with forests, most of the water, even from heavy rains and melting snow, sank into the decaying vegetation of the forest floor. There was little water left to run off as floods. Now conditions are very different. In Southern Ontario only about five per cent of the land has been left in woods. Snow melts quickly on bare fields, but the water cannot soak into the frozen ground. Then come spring rains. Without trees or grass to stop the water running off, or to help it soak into the soil, and without the decaying vegetation of a forest floor to absorb it, much of the water rushes away, down every little slope or valley, until it gathers at the nearest river.

Downstream the volume of water becomes so great that the river banks cannot contain it. Once over the banks, the water becomes a devastating flood, covering farm lands, submerging city streets, and filling cellars. Rising higher and higher, it drives families from their homes, destroys their property, brings business to a halt, washes out crops or covers them with mud, overflows highways, pushes out bridges, and undermines railway tracks. Such flood waters destroy plant life, bring hardships to farm stock, and destroy the homes and food of wildlife. Wherever floods go, they leave a trail of destruction, even death behind them.

Once started, a flood is difficult to control. The people of Winnipeg, those who live along the shores of the Grand River in Ontario, and millions of others in the valleys of streams varying in size from a mere creek to the mighty Mississippi River, know from costly experience that floods, once on their way, cannot be stopped. Huge banks of earth, called dikes and levees, may hold the water for a while. Sooner or later it is likely to break through.

Nature has taught man how to prevent floods. Marshes, swamps, lakes, and ponds all hold back spring waters and prevent them from overflowing stream banks. Forests on hilltops trap the water in spring instead of letting it run off, then feed it out gradually to streams throughout the summer. We can help Nature to prevent floods by reforesting the hills, and by building dams to form artificial lakes in the tributaries that feed the swollen streams in spring.

WATER CAN BE STORED FOR FUTURE USE. Nature has taught man how to store water for the future. The soil of forests and grasslands, the swamps and marshes, the ponds and lakes, have served always as Nature's storage reservoirs for useful water.

Swamps and Marshes. Nature stores large quantities of water in swamps and marshes, then gradually feeds it out to fill streams and to keep the water table high in the surrounding areas. At the same time, swamps and marshes provide homes, protection, and food for many useful wild animals. We have gradually learned by experience that it is often better to leave swamps and marshes to serve these purposes than to drain them to grow agricultural crops.

Natural Lakes and Ponds. Natural lakes and ponds receive and hold much of the water from melting snow and spring rains. Not only do they keep it from rushing away to larger rivers, perhaps as floods, but they gradually feed the stored water to streams throughout the summer. Where there are forests, the ample supplies of ground water keep the ponds and lakes filled. Where man has cut the forests, the ponds and lakes may dry up in summer.

Beavers have taught us how dams across streams can make new ponds to store more water. After we had cut the forests and driven away many beavers, our governments came to realize how much the beavers could help us to store water, and passed laws to protect them.

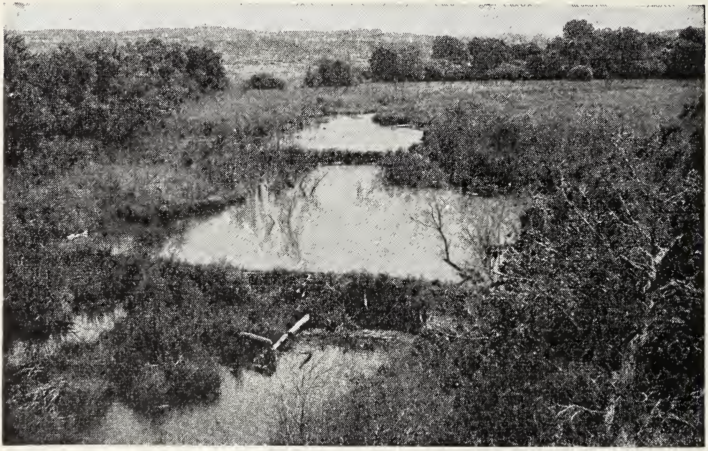


FIG. 7-7. BEAVERS CONSERVE WATER BY MAKING DAMS.
In five years after beavers were taken to this stream the ponds formed by their dams raised the water table so much that the soil produced excellent hay where it had been too dry for crops previously.

Man-made Lakes and Ponds. Man, too, makes new ponds and lakes by building dams across rivers. These dams hold back some of the spring flow of water, preventing floods and storing water for later use.

The Shand Dam, across the Grand River, near Fergus, Ontario, built at a cost of two million dollars, forms Belwood Lake. By holding back much of the spring rush of water, this dam helps to prevent floods along the Grand River. By gradually feeding the water back into the river, it keeps the stream flowing steadily throughout the summer. Six similar dams along the seventy-mile stretch of the Souris River in Southern Manitoba have restored marshes and wild life, provided increased water supplies, improved swimming and boating in summer, and increased the values of the nearby farms.

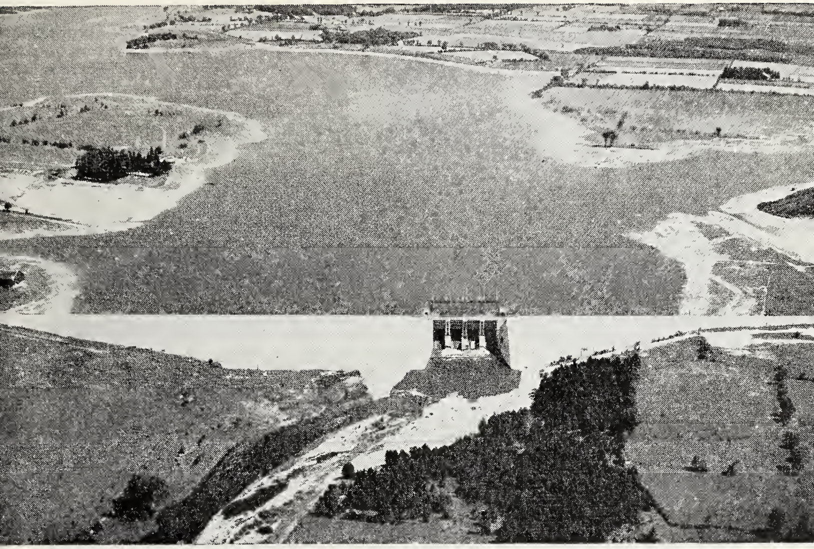


FIG. 7-8. THE SHAND DAM AND LAKE BELWOOD.
Built across the Grand River, near Fergus, Ontario, this dam greatly reduces spring floods and stores enough water to keep the river flowing freely all summer.

Farm Ponds. Well-planned farm ponds (fig. 7-9) have many values to farmers. The water in them can be piped to stables or watering troughs for livestock. By keeping the water table in nearby soil higher, they help to produce better crops. They make swimming, boating, skating, and fishing possible for farm children. The water in farm ponds is readily available for fighting fires. In addition to these benefits, farm ponds provide food and protection, and perhaps a home, for useful wildlife.

Farm ponds are usually found in low areas where they take in water from their surroundings. Some are dug, then become filled with run-off water; others are fed by springs; still others are made by building dams across small streams. Dugouts in the Canadian West are often constructed near windbreaks so that the water from melted snow may fill them in spring.

Farm ponds and dugouts conserve water that otherwise would run off. They raise the water table and improve crops, store water for stock, provide suitable homes for fish and water birds, and afford opportunities for swimming, fishing, boating, and skating.

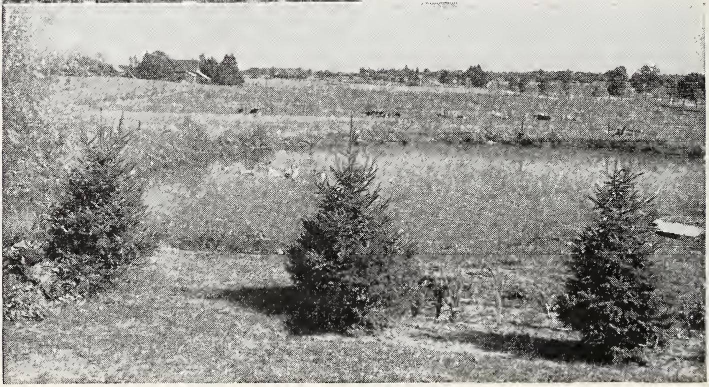


Fig. 7-9. An Eastern Farm Pond and a Western Dugout.

The best farm ponds are surrounded by trees, shrubs, and grass. Then they are unlikely to become filled with silt eroded from surrounding slopes. Of course, they should be fenced to keep livestock from entering them and contaminating the water. When farm ponds are kept clean and the water in them fresh, they can be successfully stocked with fish.

WE MUST PREVENT WATER FROM BEING WASTED BY POLLUTION. Water may be plentiful, yet so impure that it is not merely useless, but harmful to people, livestock, and wildlife. Therefore, it is important that we take every precaution to prevent our water supplies, whether they be wells, springs, rivers, or lakes, from becoming polluted.

The water in wells may become contaminated by filth or germs that enter them from the top or through the soil. Spring water, pure when it comes from the earth, becomes unfit for use if impurities from livestock or from other sources enter it. In the next chapter we shall learn how to keep safe the water of wells and springs.

Frequently, rivers and lakes are polluted by sewage from communities along their shores. In some places, factories and mines empty wastes into the nearest stream. Boats occasionally permit oil to pollute water. Sometimes we are guilty of throwing garbage or rubbish into streams. When water has become sufficiently polluted by any of these means, we put up signs reading "No Bathing: Water Unsafe", showing that pollution has deprived many people of recreation. How greatly it would benefit all if better methods were used to dispose of refuse, sewage, and factory wastes!

Many streams, once crystal clear and teeming with fish, have become muddy, lifeless waterways. Soil eroded from nearby fields caused this damage. Muddy streams let in so little sunlight that green plants cannot live in them. When streams lack green plants, fish and other kinds of wildlife no longer inhabit them. We can keep streams free from mud by preventing erosion.

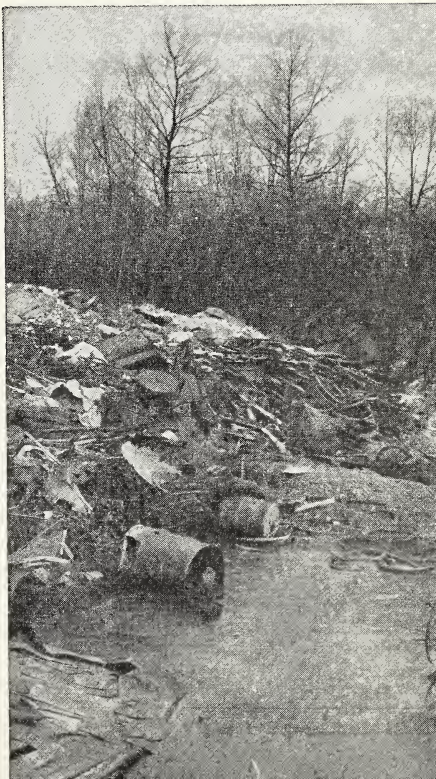


Fig. 7-10. A Beautiful Stream Spoiled by Pollution.

Rubbish, garbage, eroded soil, and factory wastes change streams of fresh, clear water—good for man and wildlife—to unsightly, unhealthy wastes.

Streams and other water supplies are very important to us. When they have become contaminated, they are either useless or harmful.

Play Your Part in Preventing Contamination of Water

1. Find out what laws have been passed to prevent contamination of water.
2. Investigate the sources of contamination of local streams and water supplies.
3. Make a list of ways in which you and your fellow-pupils can help to keep the water in streams pure. Then try your best to do these things.

Community Planning To Conserve Water

In Canada we have reached the time when many communities must make definite plans to conserve their water resources in soil and stream. As an example of what can be done, the plan for one district, namely the valley of the Don River where it approaches Lake Ontario, is described below.

The Don River Valley has an area equal to nearly a thousand 100-acre farms. Here some of Ontario's first pioneers settled, cut the forests, and cultivated the land. As time passed, spring floods became more and more frequent and costly, wells and streams went dry in summer, erosion increased, and pollution of the Don River by soil and sewage made it unfit for fish, and unusable by man.

The Don River Conservation Plan was prepared to restore some of the original beauty and other values of the region. The new forest, planned to cover nearly three thousand acres, will help to conserve both water and wildlife. The two artificial lakes will prevent spring floods and store spring water for summer use. When this plan has caused the waters of the Don River to remain free of pollution by mud and sewage, and to flow abundantly again throughout the summer, this river will again provide a home for fish, and recreation for people.

Such a plan is needed in many other river valleys.

Some Pupil Investigations

Where To Go and What To See	What To Do
A Schoolyard during and after a Rain	
Water carrying mud on paths Gullies forming under eaves Water dripping under trees	Collect and compare samples of water running from grass-covered land and from bare soil; then let the muddy run-off water settle.
Gentle rain slowly seeping into the school garden	Dig into the ground to see how deep the water penetrated.
Heavy rain washing soil from the school garden	Compare the amounts of soil washed from grass-covered and from bare soil.
A Creek after a Heavy Rain	
The muddiness of the water	Find where the mud came from.
Where pebbles and soil are dropped	Discover what causes the soil to settle from the water.
How the creek wears away its banks	Find out whether the roots of trees on the banks help to prevent the banks from being worn away by water.

Topics for Talks, Discussions, or Compositions

1. Water — the Key to Conservation
2. How I Can Help To Conserve Water
3. Water, Our Greatest Need

Conservation Activities for Autumn

1. After visiting a farmer who practises conservation of soil and water, write an article for the school paper describing his activities and the results he gets.

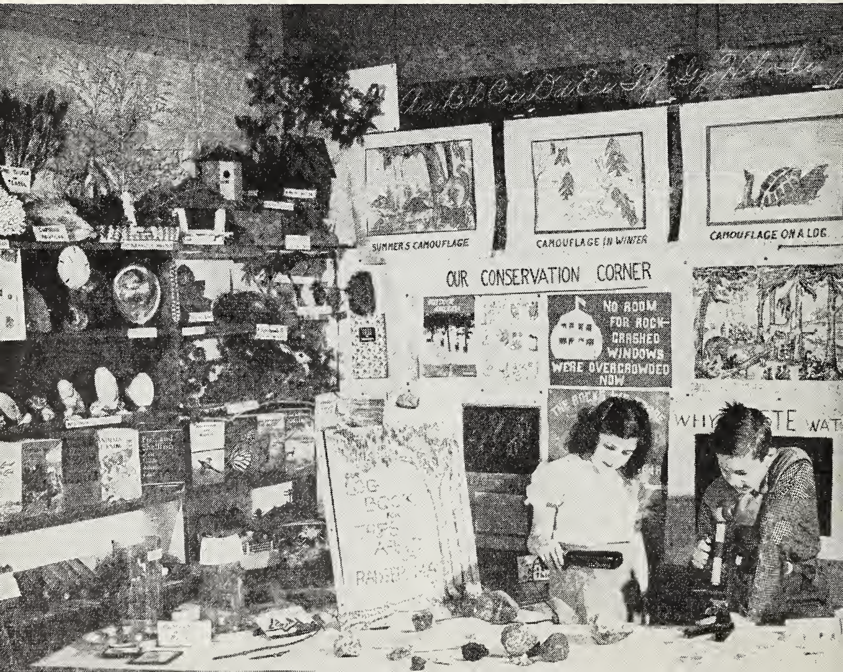
2. Make a map of your community, showing: wooded areas, grass-covered areas, cultivated areas, hillsides, and level land. On the map mark in red the places and areas where most erosion takes place.

3. Make a sketch of a local stream, its tributaries, and the whole area drained by it. Mark places: where floods are common; where erosion is serious; where dams might be built to store water in spring.

4. Make a map or a list of all the lakes and streams in your community. Try to find out how these have been used by man. Is there evidence that they have become polluted or destroyed? Discover where there were formerly streams but are none today. Try to explain this.

5. Interview citizens who have lived several years in your community and find out: how wells and springs have changed; how the sizes of streams in summer have changed; whether crops are better or poorer in recent years; how the water table has lowered or risen; what has been done to conserve water.

Fig. 7-11. A Conservation Corner for Your Classroom.



6. Plan a table entitled *Erosion by Water*, with three columns headed: *Location and Nature of Cultivation, Autumn Observations,* and *Spring Observations.* In the first column, list such types of places as: Level Grasslands, Sloping Grasslands; Level Cultivated Fields, Sloping Cultivated Fields; Slopes Cultivated Up and Down Hill, Slopes Cultivated Crosswise. Make and record observations in early autumn, late autumn, early spring, and late spring to discover what effects (1) sloping land, (2) a cover of grass, and (3) cultivation across the slope has upon the amount and rate of erosion.

7. Arrange and maintain a conservation corner in your classroom like that shown in fig. 7-11.

8. Here are some autumn activities to conserve water and soil on the farm.

(a) Plough only flat or gently sloping fields in the fall; leave steeper land for spring ploughing.

(b) Leave fall-ploughed areas rough or ridged crosswise to stop the flow of water down hill.

(c) Leave strips of sod across the slopes of cultivated hillsides.

(d) Leave strips of sod in all valleys that carry water from fields.

Review Exercises

1. List all the things you can think of that would slow down the journey of a raindrop to the ocean. Here are two to start with: leaves of trees, a bend in a river.

2. What conditions are likely to bring about excessive run-off of water, causing erosion and floods?

3. Name three ways in which water that soaks into the soil may again reach the surface or go back into the air.

4. Explain what you understand by: surface water, ground water, water table, spring, erosion.

5. What conditions cause the level of the water table to change from time to time in any locality?

6. Explain how swamps and marshes, usually found at the source of a stream, help to keep it from drying up in summer.

16 mm. Sound Films

Seeds of Destruction (colour) (SG-44)
Ontario Visual Education Branch.

Water for the Prairies (colour)
National Film Board, Ottawa.

Ground Water
Associated Screen News Limited, Toronto.

Film Strips

The Beaver (colour)
National Film Board, Ottawa.

MY Son, I admoniſh you to cheriſh the little waters, for theſe repleniſh the mighty rivers which nouriſh our thirſty land.

8

WATER CONTRIBUTES TO HEALTHFUL LIVING

NOURISHING FOOD TO EAT, fresh air to breathe, and water to serve many daily needs are essential to living. Of these three, an adequate supply of good and safe water contributes much to healthful living.

Providing a Safe Water Supply

A GOOD WATER SUPPLY IS ESSENTIAL TO LIVING. How to obtain a good water supply has always been one of man's chief concerns. It was often a problem with explorers. Pioneers made their settlements where good water was plentiful. Today city and rural people alike still look upon an adequate supply of good water as the first essential to healthful living.

Good drinking water has certain characteristics. It should be colourless and free from sediment, without objectionable taste or odour, and free from bacteria and chemicals harmful to health. Water for other domestic purposes should not contain so much mineral matter that it wastes soap or causes harmful scale in pipes or kettles; neither should it contain enough iron to cause it to leave rust stains on clothes or washbasins.

The average Canadian citizen uses more than 100 gallons of water a day. What he drinks may amount to only a quart or two; the rest is contained in his food or used for cooking, washing, watering the lawn, or flushing the street. It is essential that every person has enough water at all times to meet all these needs. One of the first requirements of a rural home is a well which will supply enough water through all the seasons. The council of a city or town establishes a waterworks department with the responsibility of providing an adequate supply of water.

SOURCES OF WATER FOR DOMESTIC USES. All the water we use comes from clouds as rain or snow. If we collect it as it falls, we call it rain water. Taken from lakes and streams, it is known as surface water. When we take it from wells and springs after it has seeped through the soil, we call it ground water.

Rain Water

EXPERIMENT 8-1. Test some rain water for purity.

Catch a few raindrops on a perfectly clean piece of glass and leave them to evaporate in a place free from dust. Account for the dirty spots on the glass where the raindrops were. Where would rain water be purest — in city or country? Why?

The water in rain and snow is formed by the condensation of water vapour in the air. Therefore, it is pure except for dust and other particles taken from the air or from roofs. Most rural people use rain water for washing purposes. In some parts of the world rain is the chief source of fresh water, and no other type is available to those who live in Bermuda. Rain water should be kept as pure as possible by letting the first water from a rain wash the dust and dirt from a roof before we begin to collect water. Then we must be sure that the cisterns or other containers in which we store rain water are kept clean.

Surface Water. Most cities and towns use surface water, taken from rivers, lakes, and man-made reservoirs. The water of the Great Lakes supplies the needs of most cities along them, including Toronto, Hamilton, and Kingston. The city of Fort William obtains its supply of water from a lake on a nearby mountain. Many places in British Columbia obtain their water from similar mountain lakes. Such water supplies are likely to be free from contamination by people. Many other cities and towns in Canada use the water from the nearest lake or river. Where no large stream or natural lake is close by, an artificial lake or reservoir may be made to store water from smaller streams and to provide a constant and adequate supply.

Surface water taken from lakes and rivers with settlements on their banks should be used only with caution. It is frequently so contaminated by sewage and by waste materials from vessels and industries that it is both unpalatable and unsafe. Water from these sources must, therefore, be purified before it can be used with safety.

Ground Water. Water stored beneath the surface of the earth is the source of supply for many communities. Wells and

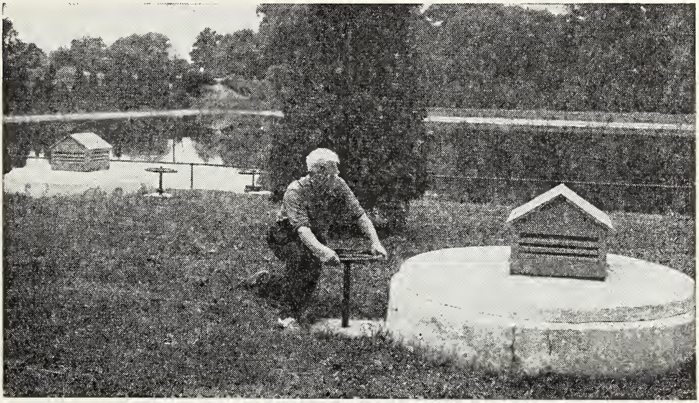


FIG. 8-1. THE WATER SUPPLY FOR STRATFORD, ONTARIO.
Six of these wells, each between 400 feet and 500 feet deep, supply the city with cool, safe water.

springs provide the water used for drinking and cooking in most rural homes. London, Kitchener, and some urban centres elsewhere throughout Canada get their water supplies from artesian wells. Water from such underground sources is likely to be colder, clearer, and safer than water taken from surface streams.

As ground water seeps through the soil to the water table, some sediment and impurities, including some bacteria, are filtered out by the soil, leaving the water clear and comparatively free from harmful germs. To contain water, a well must be dug deep enough to reach the water table. It may be much deeper, even extending below the hard layer of clay or rock which lies under the ground water.

Wells are classified according to their depth and according to the ways they are made. *Shallow wells* take ground water from above the first hard layer of rock or clay. For this reason the water in them is more frequently contaminated than the water in deeper wells. *Deep wells* reach below this first hard layer. They usually contain purer water, because it has been filtered through more earth, and because it has been protected from surface impurities by the hard layer of rock or clay above it. *Artesian wells* are deep wells from which water gushes forth as from a fountain. Any well from which water flows naturally, without being pumped, is called a *flowing well*. It may vary in depth from a shallow well to a deep or artesian well. Water must be pumped from other types of wells.

Wells are made by digging, driving, boring, or drilling. Dug wells, made by hand tools, are usually a few feet in diameter and seldom more than 30 feet deep. They often fail in time of drought. A driven well is made by driving iron pipes into the ground where it is free from rocks until a supply of water is reached. A bored well is made by boring a hole in the ground with an earth auger which brings the soil to the surface, then inserting piping. Bored wells may go dry in long dry periods. A drilled well may pass through hard

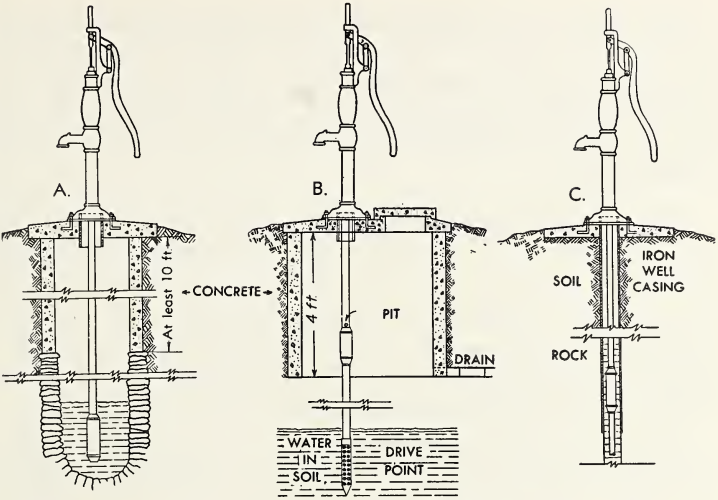


FIG. 8-2. THREE TYPES OF WELLS.
A, a dug well with concrete top and wall; B, a driven well properly protected; C, a drilled well properly protected. The concrete top and the surrounding soil should always slope away from the pump.

layers of rock, even several hundred feet deep. Such a deep well gives water when other kinds of wells fail.

PUPIL INVESTIGATIONS. Visit or investigate the lake, river, wells, or reservoir from which your community gets its water.

Is the supply adequate all through the year? How pure is the water? If the water supply comes from a lake or reservoir, find out whether this is filling up with silt. If the water comes from a river, find out whether the water may be contaminated by sewage farther upstream. If the water comes from wells, find out whether its supply has been decreasing in recent years.

SAFE AND UNSAFE WATER. To be safe, water must be free from bacteria and other living things that may cause disease. If any one of these is present in water, it is unsafe. Water may be crystal clear and sparkling, and have no undesirable taste or odour, but still be polluted sufficiently to be dangerous.

Safe water is not necessarily pure. Only distilled water, formed from steam or water vapour, and therefore without any dissolved substances in it, is pure. Water containing dissolved minerals is not pure, but it may be perfectly safe. In fact, it may taste better and be better for us than pure or distilled water.

Disease Caused by Contaminated Water. The diseases most commonly spread in drinking water are typhoid fever and dysentery. These are carried from person to person by tiny living things, commonly called *germs*. Because these particular germs are tiny plants, we call them *bacteria*. To understand better how bacteria can spread diseases by means of water, we shall find out how bacteria live.

Bacteria live almost everywhere — in air, in soil, in water, and on or in the living and dead bodies of plants and animals. They get their food from these. Bacteria are so tiny that a million could rest on the letter "o" as printed here. Under favourable conditions bacteria multiply so rapidly that a million existing when you come to school in the morning could become 250 million by four o'clock. Bacteria may be either harmful or helpful. Those that cause disease are harmful; those that help decaying plant materials to form humus and then useful plant foods are beneficial.

In our study of water we are concerned almost entirely with the harmful bacteria that spread disease. Because they are so tiny, we can neither see them nor strain them from water. Because they can withstand most temperatures and go on multiplying in water, they make the water increasingly dangerous to us.

How Water Is Tested for Safety. It is very difficult for us to test water for safety. Scientists are able to make such tests readily with the special equipment they have at hand. Seldom do they actually discover the bacteria of typhoid fever and dysentery, but their scientific tests show whether the water has been polluted by sewage. If it has, it may contain these disease-causing bacteria. Such water is unsafe.

If we have any doubt about the safety of water, we should have it tested by the Provincial Department of Health. Write first for instructions and a container in which to send a sample of the water to be tested. The Department will test the water, then advise you whether it is safe for use, and what other precautions you should take concerning it.

A "Safe Water" Campaign!

Write to the nearest Provincial Department of Health, or arrange with the local Medical Officer of Health, to have the water used at school, and that in several wells of the community, tested for safety. Be sure that all instructions are carefully followed so that you may know how safe the local water supplies are, and how to improve them if necessary.

How Water Is Contaminated. Water is contaminated in several ways by disease germs and other impurities. The body wastes of diseased persons may enter the soil and then be carried by ground water to rivers or wells. From many cities and towns the sewage is emptied into the nearest creek, river, or lake. In these, the germs may be carried into the water systems of communities farther down the stream. Severe epidemics of typhoid fever have begun in this way. The water in wells without water-proof tops may be contaminated by surface water seeping through the soil or running off the surface into them. If this water comes from places frequented by livestock, or from near outdoor toilets, it is almost certain to carry impurities, perhaps disease germs.

Precautions To Prevent Contamination of Water Supplies. Rivers and lakes which supply water for urban communities must be kept as free as possible from contamination. Precautions should be taken to see that wastes from vessels and from nearby industries are not dumped into the streams that feed these waters. The sewage of communities farther upstream must be disposed of safely instead of being added to the water flowing by them.

Many large cities bring their water from distant sources rather than risk using nearby water which may be contaminated. Glasgow's water supply, taken from Loch Katrine, is so safe that it is merely filtered before being used. As mentioned above, Fort William obtains safe water from a small lake nearby. The water for the eight million people of the city of New York is likewise taken from mountain regions a hundred miles away, stored in a large lake-like reservoir, then taken through large aqueducts and tunnels to the city.

Spring water, usually safe when it comes from the ground, may later become contaminated. To keep this water unchanged after it reaches the surface, the spring should be fenced to prevent livestock from coming close to it, and encased in some way to keep out impurities from other sources.

Wells should be carefully located and correctly constructed to prevent the water in them from becoming polluted. If wells are located on land high enough that the ground slopes away from them in all directions, surface water will be prevented from flowing towards, then into, the wells. This is especially necessary when barns or other outbuildings are near. As an added precaution, wells should have waterproof, concrete tops. To keep out impure or dangerous surface water, a well should have a water-tight casing or wall extending at least 10 feet into the ground.

HOW WATER IS MADE SAFE TO DRINK. Unless we are sure water is safe to drink, we should consider it unsafe. In the country we often take water from a well or spring and use it without question. We would be much wiser to have it tested for safety, then, if necessary, make it safe before using it. In cities and towns an expert staff sees to it that our water supply is made safe. We should understand how they do this.

Home Methods of Making Water Safe. In rural homes and in many summer cottages the only sources of water are wells, springs, and nearby lakes or streams. Even when water from these sources appears clear, it should be treated to kill bacteria in it before using it for drinking or for preparing food. Boiling such water for 20 minutes will make it safe to use. Boiling water drives the air out of it and makes it taste "flat". The original taste can be restored to the water by cooling it, then stirring it vigorously to dissolve more air in it.

Water may be made safe in the home by disinfecting it to kill any possible bacteria in it. Usually some chemical containing chlorine is used. Ten to twelve drops of Javelle water stirred into two gallons of water will kill any bacteria in it. Cover the treated water and allow it to stand 30 minutes before using it. Chloride of lime or calcium hypochlorite, sold by druggists, may be used, but accurate directions for its use must be obtained and carefully followed.[1]

Methods of Making the Community Water Supply Safe. Impurities in water are of two kinds, visible and invisible. Visible impurities, called *sediment*, consist of undissolved particles of soil or of plant or animal remains. Impurities such as bacteria and dissolved minerals are invisible. Disease-causing bacteria are harmful and must be destroyed to make water safe. Dissolved minerals may improve the flavour of water.

Nature teaches us how to make water safe. Visible particles settle to the bottom when water stands for a lengthy time in lakes. They are filtered from ground water as it passes downward through the soil. Air and sunlight kill some bacteria while water flows along or tumbles over waterfalls. Unfortunately, these methods do not kill all bacteria in water. To provide a safe water supply for all citizens, the Waterworks Department of a city or town copies Nature's method of purifying water, then adds chlorine to kill bacteria.

---

[1] To prepare a stock solution of calcium hypochlorite, dissolve 2 tablespoons of it in 1 pint of water. To make drinking water safe, add 7 drops of this stock solution to each gallon of water, then cover the treated water and allow it to stand for 30 minutes.

Causing Sediment To Settle Out of the Water. The impure water, often muddy-looking, is pumped from the lake, river, or other source to the purification plant. For a while it is left in large tanks or reservoirs to allow mud particles and other sediment to settle out. This process is called *sedimentation,* and the reservoirs, *sedimentation basins.* An experiment will show us how sedimentation takes place.

EXPERIMENT 8-2. Make some muddy water clear.

(a) Stir some mud into a glass of water. Let the mixture stand for half a day. What settles to the bottom? Unless the water becomes perfectly clear, though not necessarily colourless, some tiny particles must still be floating in it.

(b) Pour off the cloudy water. Place half of it in each of two tumblers, A and B. Stir a little alum into B. Let the water in A and in B stand for an hour or two. Which became clearer? What chemical must have caused this?

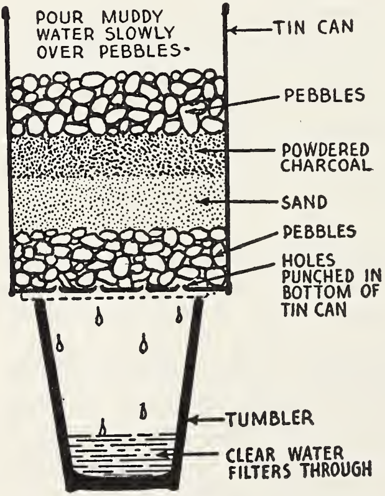

POUR MUDDY WATER SLOWLY OVER PEBBLES.
TIN CAN
PEBBLES
POWDERED CHARCOAL
SAND
PEBBLES
HOLES PUNCHED IN BOTTOM OF TIN CAN
TUMBLER
CLEAR WATER FILTERS THROUGH

FIG. 8-3. FILTERING REMOVES SEDIMENT FROM WATER.

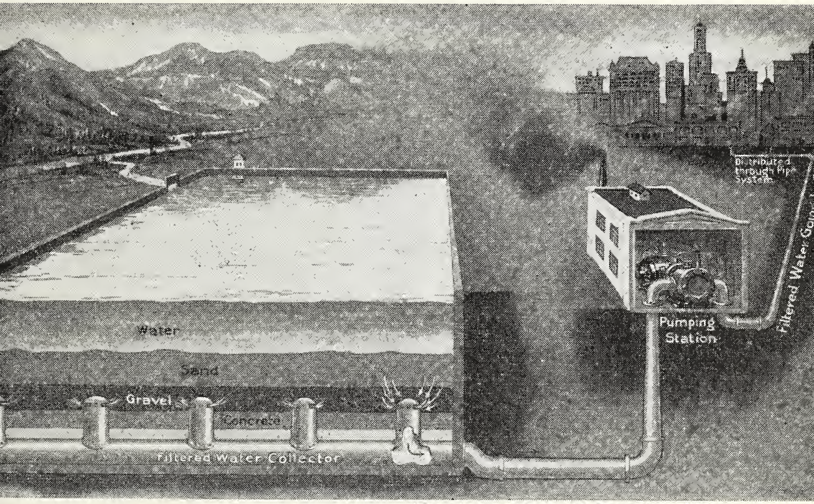
To remove very fine particles, which make water turbid because they do not readily settle out from it, alum is added to the water in the settling basins. This chemical dissolves in the water, then gathers around the particles and helps to carry them to the bottom.

Filtering the Water To Remove the Remaining Sediment and Some Bacteria. Some sediment and alum may still float in the water. This is removed by filtering.

EXPERIMENT 8-3. Filter the visible particles from some muddy water. Punch several holes in the bottom of a tin can, such as a tomato can. In this container place a layer of gravel, then of sand, then of powdered charcoal, then of gravel again, until the can is nearly full. Pour muddy water through these layers and collect the escaping water in a tumbler. Are any particles visible in the escaping water? What do you think caused the water to become clear?

In a city waterworks plant the water is pumped from the sedimentation basin to large sand filters. These are deep beds of sand, crushed stone, and gravel. As the water passes down through these layers, any undissolved particles that did not settle out before, and some bacteria too, are caught between the sand grains. The water, now clear, passes out of the bottom.

Adding Air to Water. Before it is piped to our homes, water is sometimes sprayed from a reservoir into the atmosphere so air will be dissolved in it. This helps to remove undesirable odours and to correct a "flat" taste.



(Compton's Pictured Encyclopedia)

FIG. 8-4. FILTERING WATER FOR A GREAT CITY.

Disinfecting Water To Kill Bacteria. Many disease-producing bacteria can remain alive in water that has been allowed to settle, has been treated with alum, and has been filtered. These bacteria must be destroyed to avoid epidemics of such diseases as typhoid fever. The chemical most commonly used for this purpose, and most dependable, is chlorine. This gas is fed into the water in such small quantities that it neither harms people nor makes the taste or smell of the water unpleasant. If the water is very dangerous, due to a large number of harmful bacteria in it, more chlorine is used.

PUPIL INVESTIGATION.

Arrange with the Waterworks Superintendent of your town or city to conduct your class through the waterworks plant. Ask him to tell you about these: the source of your water supply, how the water is taken from this source, how it is brought to the waterworks plant, the processes used to purify the water, how it is stored to meet emergencies, and how it is distributed to each house.

Bringing Water to Our Homes

Just a turn of the tap and we get clear, fresh water — and it continues to flow as long as we leave the tap open. Many rural homes, depending upon wells or springs for their water supply, obtain it just as easily. The Roman aqueducts, of brick and stone, carrying to that ancient city ample supplies of clear water from distant hills, helped to make Rome the greatest city of her time. Today's cities and towns may also be judged by their efficiency in supplying their citizens with adequate supplies of good, safe water.

Figures 8-5 and 8-6 show three modern methods of bringing water to our homes. In each system the water flows through underground pipes with enough pressure to throw water from a hydrant onto a fire and to serve all household needs. The two most common ways of giving pressure to our water supplies are by gravity and by pumps. Like all other things, water will always fall towards the earth when free to do so. The force that pulls it in this direction is called *gravity*.

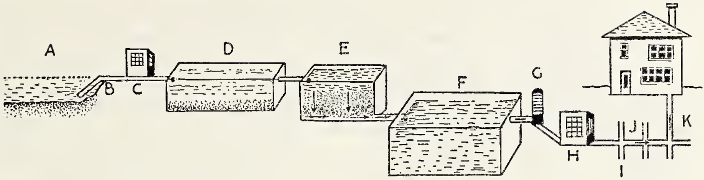


Fig. 8-5. Water—from Lake to City Homes.
A, lake; B, intake; C, pump; D, settling reservoir; E, filter basin; F, storage reservoir; G, chlorination plant; H, pump; J, water mains; I and K, branches to homes.

EXPERIMENT 8-5. Gravity causes water pressure.

> Punch three holes, A, B, and C, above each other in one side of an empty can, one hole near the bottom, another nearly half way up, and the third near the top. While holding a finger over each hole, fill the can with water. Remove all three fingers at once. From which hole does the water shoot with the greatest force? Why?

The greater the height of the water column above the outlet, the greater the pressure on the water flowing out. This pressure is caused by the weight of the water above the outlet, that is, the downward pull of gravity on it. The height of the column of water is called the "head".

Fig. 8-6 shows two ways in which water may be brought to the taps in our homes under pressure. In each, the pressure is due to gravity. When the source of water is higher than our homes, we can let gravity supply the water pressure we need. The cities of Vancouver and New York depend upon gravity to bring their water supplies to them from higher levels.

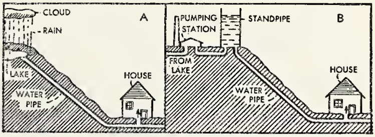


Fig. 8-6. Two Ways in Which Water Is Brought to the Home.
A. The water flows from the higher level to the house, under force of gravity. B. The water is pumped from a lake to a standpipe on a higher level than the house, and then flows under pressure of the head to the house.

Most cities and towns obtain their water pressure by means of pumps. Fig. 8-5 shows the usual method.

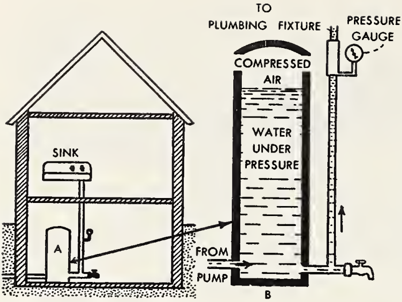


FIG. 8-7. A PRESSURE TANK WATER SYSTEM.

A, the tank into which the water is pumped under pressure; B, an enlarged drawing to show the volume of compressed air that forces the water out under pressure when a faucet (tap) is opened.

Homes that are not connected with a municipal water system can use a pressure tank system as shown in fig. 8-7. The tank always contains some air. When water is pumped from a well or cistern into the tank, it forces the air into a smaller space, causing it to press hard on the water. This pressure forces water out of any open tap.

Using Water To Dispose of Wastes

Water is essential to dispose of waste substances. When we clean our teeth, wash our bodies or clothes, or flush the toilet, we are using water to dispose of wastes. This mixture of water, body wastes, and household refuse is called sewage.

Sewage can be dangerous. It may carry harmful bacteria from the body wastes of a person ill with typhoid fever to the drinking water of other people. To guard our health and that of others, we must get rid of all sewage safely.

In large communities sewage is collected by a network of sewer pipes. In some systems it is emptied into a flowing stream where germs are gradually killed by air and sunlight. Large cities usually have modern sewage disposal plants which change sewage into useful fertilizers and safe water. The water is then set free in lakes and streams.

The safest method of disposing of sewage when there are no sewers is by using a septic tank (fig. 8-8). When sewage enters the septic tank, the solids settle to the bottom and the liquids flow through. Helpful bacteria decompose the solid materials and change them to less dangerous sludge. This should be removed every few years. The water, still dangerous, passes from the septic tank into the soil through a system of branching underground tiles laid in gravel. Seeping through the soil, the water gradually becomes filtered and made pure again, then joins the supply of ground water from which it may have come.

Water is not destroyed while serving us. Whether we use it in the home or in the field, to grow plants or to dispose of wastes, it is still water in some form. Sooner or later it goes back into streams, into the soil, or into the air — back to Nature again.

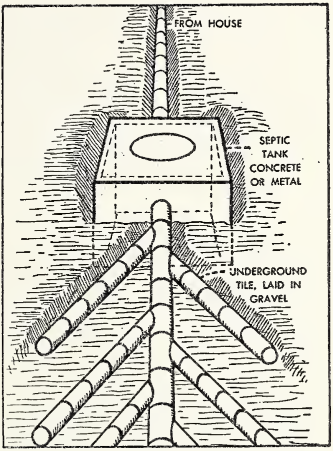

FROM HOUSE
SEPTIC TANK CONCRETE OR METAL
UNDERGROUND TILE, LAID IN GRAVEL

FIG. 8-8. HOW A SEPTIC TANK IS INSTALLED.

All parts shown in the diagram are under ground. Beneficial bacteria in the septic tank destroy sewage wastes and harmful bacteria. The escaping water seeps away from the tile into the soil.

Nature gives us water in trust. It is ours to use for a while only. Then it is our duty to return it to Nature as useful, as safe, as pure as we received it, ready to serve others as well as it has served us. We must, therefore, use water, Nature's greatest gift, wisely. This is true conservation; this is following "the golden rule".

Test Your Knowledge of This Chapter

1. From what sources do country homes usually obtain water for domestic uses?

2. By what methods may a supply of running water be provided in country homes?

3. What care should be taken to keep the water in wells and springs clean and free from harmful germs?

4. Trace the journey of water from a lake to a home in a city or town.

5. Both natural ice and manufactured ice are used in our homes to keep foods cool and fresh, and sometimes to cool the liquids we drink. In procuring and using both kinds of ice, what care should be taken to protect our health?

Something To Do

Visit an urban water supply plant to find out how the water is obtained, purified, and distributed to the people. Discuss these processes in class, using blackboard illustrations.

◆

Read

Compton's Pictured Encyclopedia: "How Modern Cities Get Their Water", Vol. 15, pp. 71-74.

16 mm. Sound Films

Water — Friend or Enemy (H-28) (colour)
Ontario Visual Education Branch.

Out Beyond Town (safe water)
National Film Board, Ottawa.

London's Water Supply
United Kingdom Information Office, Ottawa.

Sewage Disposal
Associated Screen News Limited, Toronto.

UNIT THREE

Food and Healthful Living

9. *WHAT SHALL WE EAT?*

Early man satisfied his need for food much as his animal neighbours did. As knowledge and opportunity permitted, he gradually learned to choose foods that build a sturdy body, keep it warm and active, and help it to work smoothly and keep free from disease. The experiences of the race taught man how to choose foods that give the right balance of carbohydrates, fats, proteins, minerals, and water. Science has shown him how to keep foods tasteful and nourishing for future use, and how to avoid the dangers of food poisoning.

10. *WHAT BECOMES OF OUR FOOD?*

Our food must be digested before it can nourish the body, keep it warm, and provide the energy needed for daily work and play. This process of making our food ready for our bodies to use begins in the mouth and continues in the stomach and the intestines. The blood stream absorbs digested food and distributes it to all parts of the body. Then the oxygen we breathe combines with the digested food to produce heat for the body and energy for action.

9

WHAT SHALL WE EAT?

EVERY LIVING THING, plant and animal alike, requires food. A lack of food, or the use of foods that do not supply sufficient nourishment for the body, causes hunger. Hunger has caused men to steal or commit crimes, and whole nations to migrate or to make war. Food is so important to us that we should try to understand what it does for us, how to choose it, how to care for it, and how to use it wisely.

Why Do We Eat?

Why are we hungry after a long hike? Why do we eat more in cold weather than in warm weather? Why does a growing boy often eat more than his father? Let's find out!

Our bodies are somewhat like engines. Each has to be built and kept in repair; each has to be kept going; each does its work best when all of its parts are kept working smoothly. To have a well-built, healthy body, we must eat proper foods. See figure 9-1.

FOODS FOR GROWTH AND REPAIR. Engines are built chiefly of metals which are obtained from ores. Our bodies are built chiefly of bones, muscles, and flesh. As we grow, new tissues for these have to be built. Our food builds tissues after it has been digested. Because engines wear as they are used, they frequently need repairs or rebuilding. Some parts of our bodies become worn, too, through our daily activities. Our nails show this clearly. Muscles and other parts of our bodies also become worn and need repairs. Our food must supply the raw materials to repair or rebuild these worn parts.

To build our teeth, and the bones and framework of the body, we need calcium and phosphorus. We obtain most of the calcium we need from milk and cheese. Our phosphorus comes from milk, cottage cheese, green vegetables, and oatmeal. To build flesh and muscle, we need protein. Of our protein foods, animal proteins such as those provided by milk, eggs, and meat are best. Plant proteins are provided by cereals, bread, peas, and beans. To build the blood and keep it red, we need iron. We get this from spinach, carrots, beef liver, lean beef, eggs, prunes, and raisins.

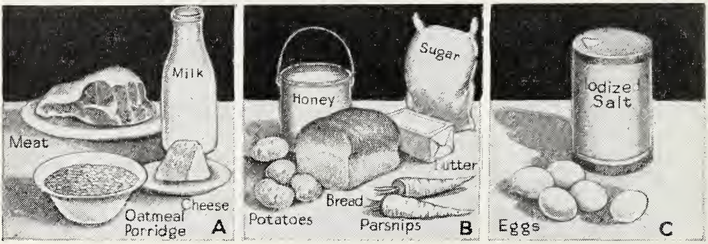


Fig. 9-1. Foods Needed by the Body.

We cannot grow and be active without all three classes of foods shown here: A, builders, or foods for growth and repair; B, fuels, or foods for energy; C, regulators, or foods to keep the body working smoothly.

FOODS FOR ENERGY. An engine uses fuel to keep going. Our bodies use fuel, too, in the form of food. This keeps us warm and provides the energy needed for the heart to keep beating, and for us to work or engage in play or exercise. The foods that supply most energy are fats, starch, and sugar. Butter, cream, and fat meat give us fats; bread, potatoes, and parsnips give us starch; honey, fruits, and table sugar give us sugar. These three, fats, starch, and sugar, keep us warm and enable us to do our daily tasks.

FOODS TO KEEP THE BODY WORKING SMOOTHLY. Engines need oil to run smoothly. Our bodies need regulating foods to remain healthy and to work well. Regulating foods help our bodies carry out digestion, dispose of body wastes, and make growth. Brown bread, iodized salt, and eggs are useful in these ways.

PROTECTIVE FOODS. Disease is hated and dreaded by man and beast alike. Pasteur, Koch, and Curie spent their lives trying to prevent and cure it. Modern scientists have found substances in our daily food that help greatly to prevent disease. These are known as *vitamins.*

The food we eat may be sufficiently nourishing to keep the body growing normally, to maintain the correct weight, and to supply all the energy we need. At the same time this food may lack some of the vitamins needed to keep us healthy by helping to protect us from disease. Foods that contain such vitamins are called protective foods.

In planning meals we should give first place to protective foods, especially to milk and cheese, fresh fruits and vegetables, bread and whole grain cereals, and meat, fish, and eggs. Fig. 9-2 shows you some good protective foods that you should eat to obtain enough of the health-protecting vitamins.

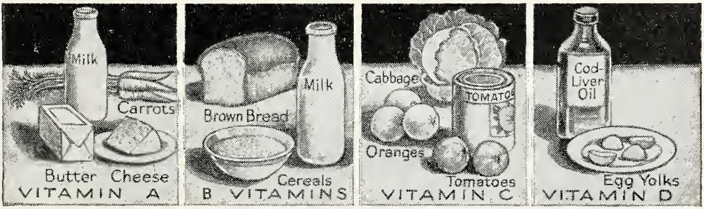


FIG. 9-2. PROTECTIVE FOODS.
Vitamins in our foods help to protect us from diseases.

What's in Our Food?

Foods are made up of six important kinds of substances or nutrients: carbohydrates, fats, proteins, minerals, water, and vitamins. Some foods contain all of these nutrients; others lack one or more of them. These nutrients are present in different kinds of food in different proportions. Milk is an excellent food because it contains all six of the nutrients.

CARBOHYDRATES. Starches and sugars are called carbohydrates. They are used in the body, somewhat as fuel is burned in an engine, to produce the heat that keeps our bodies warm, and the energy with which we move about and do our work. If too much starch or sugar are eaten, they are changed to fat and stored as such in the body. Cornstarch, corn syrup, honey, and the various kinds of sugar we use are almost pure carbohydrate. Other foods that contain much carbohydrate are potatoes, root vegetables, flour, oatmeal, rice, ripe or dried fruits, candy, cake, and breakfast cereals.

FATS. Fats are our best energy-producing foods. Therefore, foods containing much fat are good for those who work hard physically. Most people require little fat in their food. Foods that are almost entirely fat include shortening, lard, fat meat, and vegetable oils. Other foods containing much fat are butter, cream, egg yolk, nuts, pork, and margarine.

PROTEINS. Foods rich in protein are absolutely essential for our growth. Seeds contain much protein, stored there by nature, ready to feed the growing young plant. The proteins in milk make young animals grow.

Proteins are essential to people for the building of muscles and healthy, firm flesh, and for the repair of body tissues. The best sources of highly nutritious proteins (animal proteins) are meat, eggs, and milk. We obtain less valuable proteins (plant proteins) from peas, beans, soy beans, rice, peanuts, peanut butter, and cereals.

MINERALS. Minerals are essential in bones, teeth, blood, and body fluids. Calcium and phosphorus give hardness and strength to bones and teeth, but they must be assisted by vitamin D. Calcium, iron, and copper are important in blood.

Without calcium, blood will not clot to stop bleeding; without enough iron and copper, a person develops anemia. Insufficient iodine in food may cause goitre. For this reason, manufacturers frequently add iodine to salt.

To eat foods rich in calcium is especially important. The bones of a boy at the age of seven contain about 1⅔ pounds of calcium; at twelve, 2⅔ pounds; and at the age of seventeen, 5 pounds. In the five years from the age of seven to the age of twelve a boy's food must provide, for the growth of his bones alone, a pound of pure calcium; for the five years from twelve to seventeen, more than two pounds of calcium. Milk is the best food source for calcium; cheese and green vegetables are good sources.

Minerals are so important to us for growth and health that we must use foods that will provide all of the nourishing minerals in large enough amounts. Milk and cheese are the most important sources of calcium and phosphorus. You should use from 1 to 1½ pints of milk each day as a beverage and in foods. Iron is plentiful in dried fruits, leafy vegetables, and eggs.

The amount of calcium and phosphorus in our foods depends upon the amount in the soil in which the grains and vegetables were grown, and from which our milk and meat were produced. Soils that lack calcium and phosphorus produce foods poor in these minerals.

WATER. Man can live a much shorter time without water than without food. The water in fruit juices and milk helps us to take in the important minerals and vitamins they contain. Water assists in digesting all foods. As a part of the blood, water helps to distribute digested food throughout the body, and to collect and dispose of body wastes.

VITAMINS. About half a century ago it was discovered that animals died when given food containing only pure carbohydrates, fats, proteins, and minerals, but that they lived when given a little milk along with these foods. The vitamins in the milk (a protective food) caused the difference. Since then, many new vitamins have been discovered and named. The names most commonly used are vitamin A, the B vitamins, vitamin C, and vitamin D.

All four vitamins are essential for the normal growth and development of the body. The B vitamins must be supplied with our food in adequate amounts to help the body use carbohydrates, fats, and proteins, and to keep the body healthy. Vitamins A and C help to protect us from disease. Vitamins C and D are required with calcium and phosphorus to build sound bones and hard teeth.

We obtain all vitamins, except vitamin D, if our food includes sufficient milk, butter, cheese, eggs, meat, fresh vegetables, ripe fruits, and fruit juices (fig. 9-2). Cod-liver oil is necessary to provide some vitamin D.

Investigate These

1. The discovery by the Japanese Navy that the disease, beriberi, could be cured by feeding the men whole rice, or by adding some of the outer part of rice kernels (containing vitamin A) to their food.
2. The cure of scurvy among Cartier's men at Quebec during the winter of 1534-1535 by giving them a preparation made from spruce bark (containing vitamin C), on the suggestion of an Indian.
3. How we can prevent vitamin C from being destroyed when we cook vegetables and fruits.
4. Why doctors recommend cod-liver oil as a source of vitamin D, especially for people who do not spend much time in sunlight.

A Guide to Good Eating

CANADA'S FOOD RULES. Each person's health is determined to a considerable extent by the food he eats. Good food, eaten with enjoyment, promotes good health and increases efficiency at both work and play. The best advice to Canadians about the choice of foods is to follow Canada's Food Rules (page 154-155). These provide a guide to good and healthful eating.

SOME NUTRITIOUS FOODS. If we follow Canada's Food Rules, we will include in our daily menu some milk, fruit, vegetables, cereals and bread, and meat or fish. Therefore, we should learn much about each of these classes of food.

Milk and Cheese. Milk has nourished humans from birth to the grave, from ancient times to the present, and it will continue to nourish man. The sheep in Persia, the reindeer in Lapland, the goat in Italy, the camel in Arabia, the llama in Peru, the cow in our own land — these have been man's chief sources of milk.

EXPERIMENT 9-1. Why is milk such an excellent food?

1. Allow a pint of milk to stand overnight in a saucepan. Skim off the cream with a spoon. Rub a little of it on a piece of paper. The grease spot shows that the cream contains *fat.*

2. Add a teaspoonful of vinegar to the skimmed milk. Keep it in a warm place for two hours or more. The curds are *casein,* a protein of milk, used to make cheese. The liquid is whey. Strain the casein from the whey.

3. Boil the whey and skim off the thin layer of scum. This is *albumen,* another protein.

4. Heat the liquid until all *water* has evaporated. Taste what is left. Its sweetness shows that this contains *milk sugar.*

5. Heat the white residue ten minutes more. The sugar burns away. The ash contains *minerals.*

This experiment shows us that milk contains all kinds of nutrients needed in our food: fat, carbohydrate (sugar), proteins, minerals, and water. In addition to these nutrients, milk contains some of the vitamins necessary for growth and health.

Milk is the best source of calcium available for everyday use. A pint of milk each day will provide 70 per cent of all the calcium needed by children up to age 12 for the growth of bone. Teen-age young people require 1½ pints of milk each day to provide the calcium needed for their rapid growth.

CANADA'S FOOD RULES

These foods are good to eat.

Eat them every day for health.

Have at least three meals each day.

1. **MILK**
   Children (up to about 12 years) : at least 1 pint.
   Adolescents: at least 1 ½ pints.
   Adults: at least ½ pint.

2. **FRUIT**
   One serving of citrus fruit or tomatoes or their juices; and
   One serving of other fruit.

3. **VEGETABLES**
   At least one serving of potatoes; and at least two servings of other vegetables, preferably leafy, green or yellow, and frequently raw.

4. **CEREALS AND BREAD**
   One serving of whole grain cereal, and at least four slices of bread (with butter or fortified margarine).

5. **MEAT AND FISH**
   One serving of meat, fish, poultry, or meat alternates such as dried beans, eggs, and cheese.
   Use LIVER frequently.

In addition:

EGGS and CHEESE at least three times a week each.

VITAMIN D—At least 400 International Units daily for all growing persons and expectant mothers and nursing mothers.

(Prepared and approved by the Canadian Council on Nutrition)

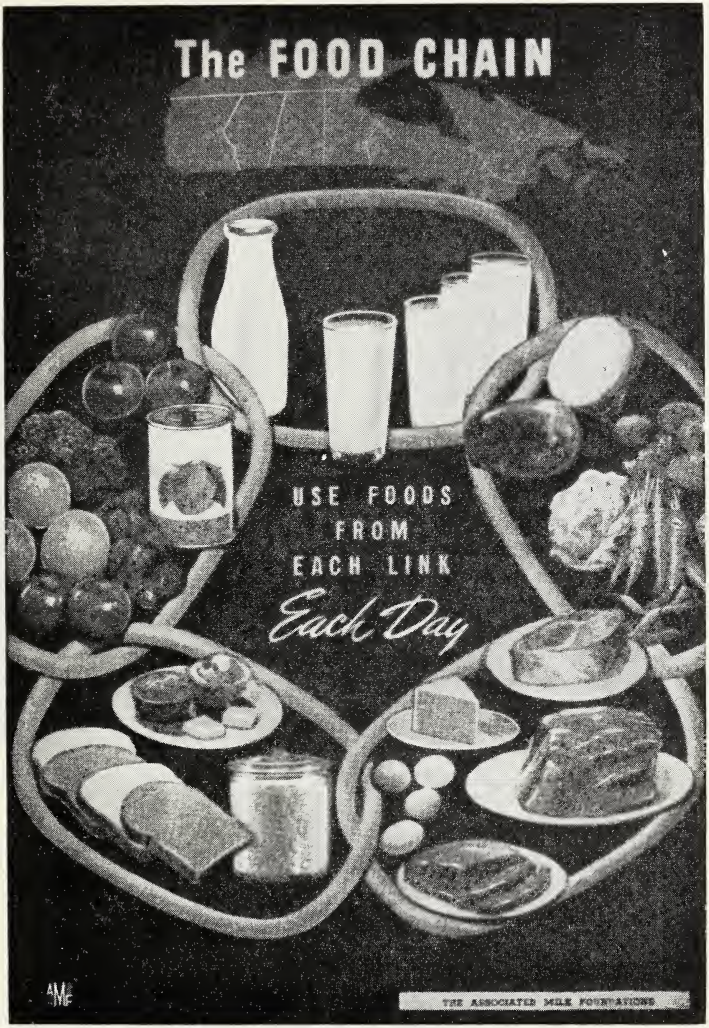

The FOOD CHAIN
USE FOODS FROM EACH LINK
Each Day
AMF
THE ASSOCIATED MILK FOUNDATIONS

Fig. 9-3.

The fat in milk makes it an energy-producing food. The vitamin A in cream promotes growth and protects us from disease. Only pasteurized milk should be used.

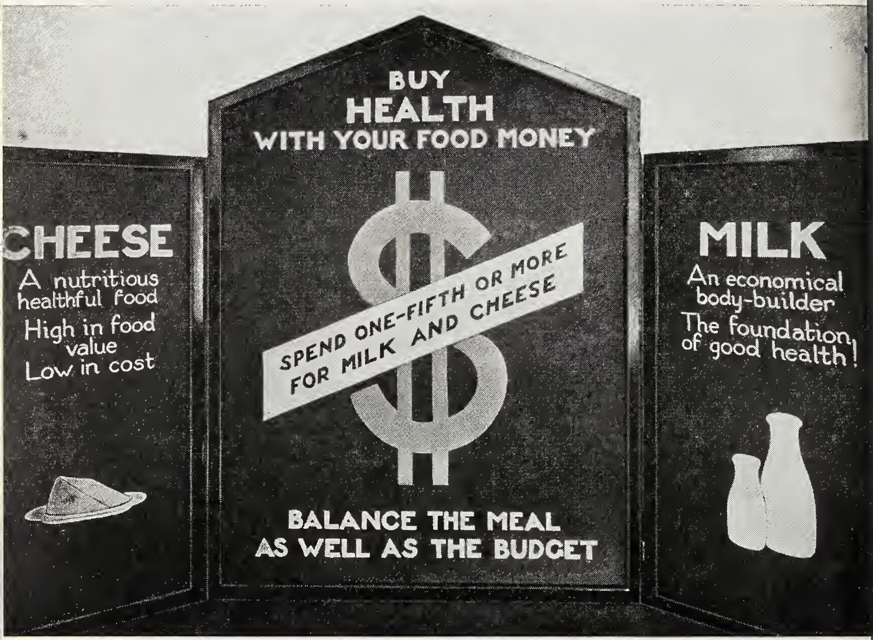


FIG. 9-4.

There is as much protein in two quarts of milk as in a pound of beef. Milk is an economical source of protein, needed for the building of muscle and flesh. Cheddar cheese contains most of the protein of milk, some calcium and fat, and B vitamins. For these reasons, cheese should be eaten at least three times a week.

Milk has the same food values whether it is served as a beverage or in other ways such as on cereals, in puddings and soups, and in creamed vegetables and meats. Skimmed milk lacks only the fat and Vitamin A of whole milk. Chocolate drink consists of skimmed milk and chocolate syrup. The extra sugar in it promotes tooth decay.

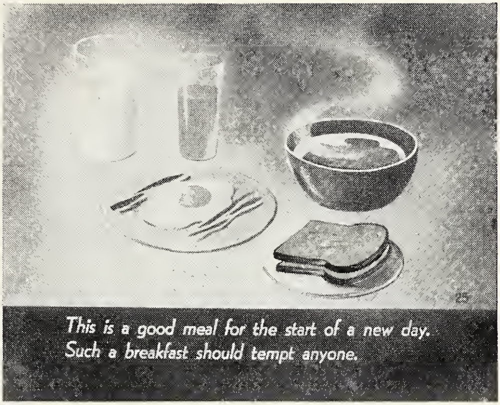

This is a good meal for the start of a new day.
Such a breakfast should tempt anyone.

Fig. 9-5. A Good Breakfast To Start the Day Right.

Milk is an excellent food. Although it is too bulky and does not provide enough iron to be our only food, no other food satisfies so many needs of the human body. Every member of the family needs milk every day.

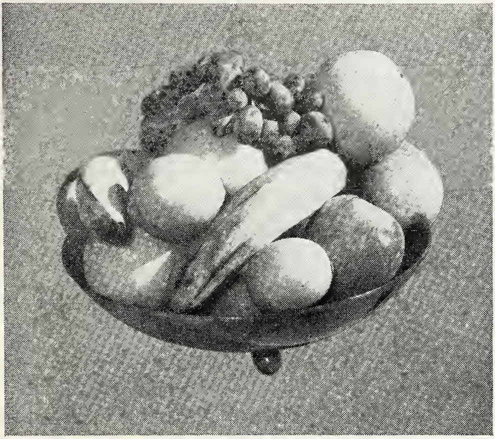


Fig. 9-6. Fruits Provide Appetizing Variety in Our Meals.

Fruit. Most fresh fruits are good sources of vitamin C. Citrus fruits (oranges and grapefruits) and tomatoes are excellent when served whole or as juice. The vitamin C in these fruits is partially destroyed by cooking and when the juices are left exposed to air.

Canned tomatoes and canned tomato juice contain only half as much vitamin C as fresh fruit juices. Each child and adult needs one medium-sized orange, or half a grapefruit, or a small glass of the juice of a citrus fruit daily.

Dried fruits and canned fruits contain about the same nutrients as fresh fruits. They have fewer vitamins because some of these are destroyed by the drying and canning processes. Dried figs, prunes, and raisins are excellent sources of iron.

Vegetables. Potatoes are a cheap source of starch, an energy-giving food. When properly cooked, preferably baked or boiled in their skins, potatoes are rich in vitamin C. Cabbages and turnips are excellent sources of vitamin C, especially if eaten raw. Green-leafed vegetables such as lettuce, spinach, and chard, also yellow vegetables such as carrots, squash, and pumpkin, are good sources of vitamin A. Most of these vegetables supply iron and other minerals.

Cereals and Bread. Cereals have always been prized as high-quality foods. Their carbohydrates provide energy, their proteins build muscles and flesh, their minerals make strong bones, and their vitamins make them protective foods. Whole-grain cereals such as rolled oats, wheat flakes, and shredded wheat contain more vitamins and more minerals than cereals that do not contain the outer coating of the grain.

Bread has been called the staff of life. Although the ancient Egyptians and early European peoples did not know that bread was more than half carbohydrates, they did know that it gave energy and promoted health.

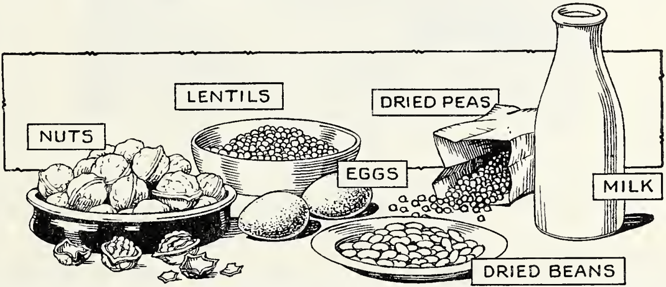
Should we eat brown bread or white bread? The starch in white bread makes it one of the most nourishing and energy-producing foods we have. Modern bakeries make it with milk and so add to its food value. Brown bread is made from whole wheat, including the outer coating of bran. Therefore, whole-wheat bread supplies vitamin B^1, iron to help make blood, and all the other nutrients found in white bread. The bran in whole-wheat bread provides roughage which helps to prevent constipation. Unless our daily menu contains enough meat, milk, eggs, and breakfast cereal to provide the minerals and vitamin B^1 we need, we should eat whole-wheat bread.

Butter makes bread taste better, and makes it more nourishing. The butter provides additional energy because it is more than 80 per cent fat, all of which is easily digested. The vitamin A in butter promotes growth.

Meat, Fish, and Eggs. We enjoy eating meat, for we like its flavour. We should eat it for its food value, too. Lean meat is muscle fibre, made up chiefly of protein. This high-quality animal protein is easily digested, then builds our muscles and flesh. It is also a good source of iron and of vitamin B^1. The fat in fat meat provides fuel for energy. Liver contains more iron, B vitamins, and vitamin A than do other meats.

As sources of animal protein we may substitute fish, fowl, and eggs. The proteins in these are more nutritious than those in cereals and vegetables. In addition to providing protein, eggs are excellent sources of iron and good sources of B vitamins. Fig. 9-7 shows some other protein foods that we may substitute for some of our meat.

Eat meat at least once a day.



(Reprinted from Junior Foods, Revised, by Kate W. Kinyon and L. Thomas Hopkins, by permission of the publishers, Benj. H. Sanborn & Co., Boston)

FIG. 9-7. SOME PROTEIN SUBSTITUTES FOR MEAT.

Vitamin D. Calcium and phosphorus cannot build bones and teeth without the help of vitamin D. Because vitamin D is essential for the making of bones and teeth, it is required by children and adolescents so long as growth continues.

Foods are not dependable sources of vitamin D. Bright sunlight causes vitamin D to form in the skin, but it is not likely to form enough to meet our needs in winter or when we spend much time indoors. Therefore, growing children should be given cod-liver oil, vitamin D tablets, or capsules containing vitamin D at all times in the year.

FIG. 9-8. A NUTRITIOUS AND APPETIZING SCHOOL LUNCH.

No meal should receive more careful preparation than the lunch that is carried to school.

THE SCHOOL LUNCH. The food in the school lunch should be chosen with as much care as the food for any other mid-day meal. A good lunch contains at least one food from each of the following four groups: milk to drink, or a milk dish;

meat, eggs, cheese, peanut butter, peas, or beans; whole-wheat bread or bran muffins; a fruit or vegetable. Some of these may be provided as a hot dish prepared at school, such as cocoa, baked beans, or vegetable soup.

Making and Keeping Our Foods Good To Eat

PREPARING AND COOKING FOODS. Good foods, carefully selected, properly prepared or cooked, and tastefully served, do much to keep us strong and healthy. Let us find out what precautions are necessary to prepare and keep good food good to eat.

Preparing Vegetables and Fruits. Cleanliness is the first essential in preparing vegetables and fruits for use. Whether they are to be cooked or eaten raw, vegetables and fruits should be thoroughly washed to remove dirt and disease germs which may have adhered to them from soil, insects, or people who have handled them. Garden vegetables may have been dusted or sprayed with chemicals to control insects or plant diseases. Vegetables should not be soaked, as this may remove some nutrients that dissolve in water.

Fruit juices should not be extracted until just before serving, or vitamin C will be lost. For the same reason, apples, peaches, and pears should not be peeled until they are required for use.

Cooking Foods Properly. Cooking serves several purposes. It makes some foods taste better, especially when salt or other flavourings are added. It increases wholesomeness by destroying bacteria that might cause decay and illness. Cooking also softens the fibres in meat, cereals, and vegetables, and makes these foods more digestible.

Much of the vitamin C in vegetables and fruits can be removed or destroyed by improper cooking and by allowing cooked foods to stand before being eaten. Vegetables should be cooked in large pieces, placed in water already boiling. As little water as possible should be used. The cooking water should be saved to be used later in soup or in gravy. In this manner, we make use of the vitamins and minerals that escape from the vegetables into the water. Vegetables taste better and retain vitamin C and nutrients to a greater extent if the time of cooking is kept short by covering the container, and if the vegetables are served as soon as they are cooked. Potatoes retain their vitamins and minerals best when they are boiled without being peeled, and when they are baked.

Meats, especially pork, should be thoroughly cooked to make certain that the tiny trichina worms, which sometimes live in the muscles of hogs, are killed before the pork is eaten.

Fruits should be cooked if there is any doubt about their cleanliness or ripeness. To conserve the vitamins and nutrients in dried fruits, all water in which they are soaked and cooked should be saved.

PRESERVING FOODS. Foods are preserved to prevent them from spoiling and to keep them fresh and palatable for use at some future time.

Why Foods Spoil. Without proper care, most foods will spoil. The spoiling of food is caused by chemical changes that take place in the food, and by bacteria or other tiny animals or plants (called micro-organisms) that live in it. Bacteria need air, warmth, food, and moisture to grow and multiply. When bacteria receive these conditions in food, they grow and multiply, making the food less palatable and less nourishing, or causing it to decay. Chemical changes in food also change its taste and its food values.

Such chemical changes as the souring of milk may be prevented by sufficiently cool conditions. Micro-organisms may be killed or prevented from multiplying in foods by temperatures that are either too high or too low for them, by conditions of dryness, and by chemicals such as salt.

How Foods May Be Preserved. One of the earliest methods of preserving foods was to dry them. Fruits such as prunes, raisins, and currants, also vegetables, such as peas and beans, are still preserved by removing the water from them. Now we remove water from milk to make condensed milk, evaporated milk, or milk powder, all of which keep well. Bacteria and other micro-organisms cannot live in dried foods because of the lack of moisture in them.

Canning preserves fruits and vegetables well. In the canning process, all micro-organisms are killed by heat, after the containers have been sealed to prevent any other micro-organisms from entering the food.

Cold storage of fruits and vegetables keeps them from spoiling, but does not change their form or taste appreciably. Milk and butter, meat and eggs, fruits and vegetables all keep well at temperatures just above freezing point. At these low temperatures bacteria do not grow or multiply. Therefore, the foods do not change much. Refrigerator cars and refrigerator trucks preserve foods while they are being transported; cold-storage plants preserve foods while they are being stored; and refrigerators or ice boxes preserve them in our homes. All of these containers must be well insulated to keep heat from reaching the food.

Some foods are preserved by means of vinegar, salt, or spices. Vinegar is a good preservative for pickles because the bacteria which spoil food do not live in it. Salt, or a solution of salt (called brine), preserves meat and olives for the same reason. Meat and other foods are preserved also by using cloves, cinnamon, and other spices. These preservatives are used for particular foods because the flavours they add are suitable for those foods.

Precautions To Avoid Illness by Foods

WE SHOULD EAT ONLY WHAT WE KNOW TO BE SAFE. Food is our greatest need; it can be our greatest hazard. A mere accident or a bit of carelessness in selecting or in handling food can lead to poisoning. Therefore, every precaution possible should be taken at all times to see that we do not take any food that can cause poisoning.

Poisoning may be caused by food in three ways. The food itself may be poisonous; good food may become harmful through improper care; poisons may accidently become mixed with our food.

Several kinds of mushrooms are so poisonous (fig. 9-9) that we should refrain from eating any kind of mushroom that we do not know to be of an edible variety.

The roots of water hemlock and of poison hemlock, both deadly poison, may be mistaken for artichokes, and eaten. Children, through curiosity, may eat the poisonous berries of red baneberry, white baneberry, bittersweet, nightshade, or Jimson weed.

Good food may become harmful through improper care. Meats and fish that have not been kept cold enough to prevent

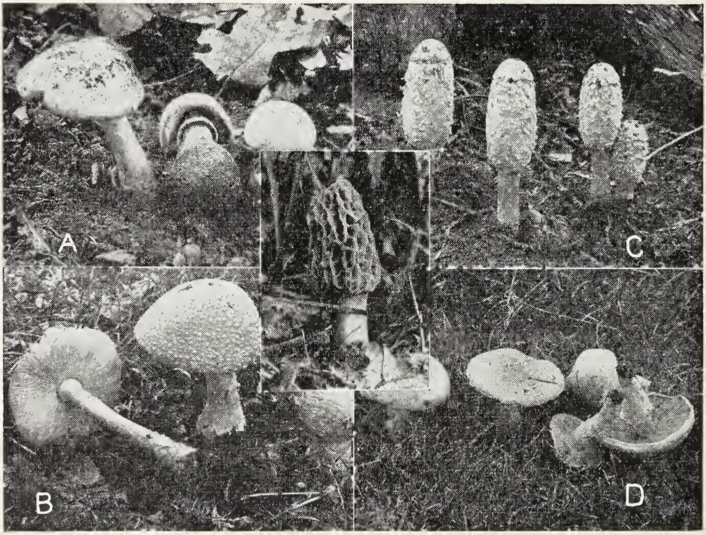


Fig. 9-9. Poisonous and Edible Mushrooms.
A, B, two Amanita mushrooms, both deadly poisonous (B, fly agaric); C, shaggy mane, edible; D, common meadow mushroom, edible; Centre, the common morel, edible.

bacteria from multiplying in them may cause food poisoning, even before they show any signs of spoiling. Foods that were improperly sterilized when being canned may contain other bacteria which make them injurious.

Dangerous bacteria from dirty hands may contaminate food while it is being handled. If the food is eaten, food poisoning may result. Because heat kills such bacteria, this type of food poisoning is most likely to come from eating cold meats that have been handled while being prepared and served.

The best precaution to prevent food poisoning is clean, sanitary conditions wherever food is kept, and cleanliness on the part of all who handle it. The kitchen must be kept scrupulously clean and free from flies. All dishes should be scalded after being scrubbed clean. Only healthy people with clean hands and fingernails should handle food or kitchen utensils.

POISONS THAT MAY CONTAMINATE FOODS. Poisonous antiseptics, insecticides, and household chemicals may come in contact with food accidentally, or may be swallowed by mistake. Bichloride of mercury, a commonly used antiseptic and usually sold as small, white tablets, may be mistaken for harmless pills. White arsenic, another deadly poison, may de mistaken for sugar. Paris green and lead arsenate, used to poison insects that eat foliage, may contaminate food unless we take adequate precautions by washing our hands thoroughly, cleansing the

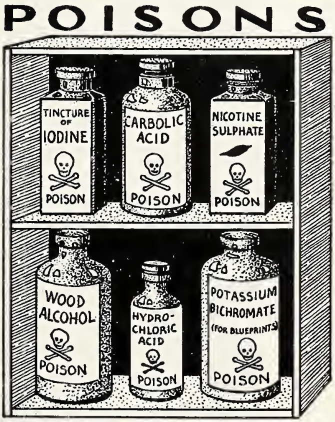


Fig. 9-10. Some Common Stomach Poisons.

Notice how clearly the containers are labelled as a precaution.

containers carefully, and storing the unused poisons safely. Other poisons frequently kept in homes are tincture of iodine (as a disinfectant), nicotine sulphate (as an insecticide), strychnine, oxalic acid, and carbolic acid.

Special precautions should be taken wherever poisons are stored. All containers should be conspicuously labelled "Poison" (fig. 9-10). They should be stored high enough to be out of reach of children. Poisons should never be kept close to medicine. No more poisons should be kept in the house than are absolutely needed. As an added precaution, we should never take medicine without reading the label on the bottle.

WHAT TO DO IN CASE OF POISONING. The usual signs of stomach poisoning are headache, muscular pains, stomach sickness, convulsions, and extreme weakness. When poisoning is suspected, a doctor should be called at once; then the patient should be caused to vomit to empty as much of the poison as possible from his stomach. This may be done by thrusting the finger into the patient's throat or by giving special liquids which cause vomiting. These are called *emetics*. Two common emetics are: a tumbler of warm water containing a teaspoonful of mustard; a tumbler of warm, strong salt solution. Repeat the doses if necessary. (NOTE: no emetics should be given after acid has been swallowed.) Keep the patient warm.

When poison has been swallowed, keep the bottle or container from which it was taken. Then the doctor will know what to give the patient to counteract the poison. Such a substance is called an *antidote*. When the poison is an acid, the antidote should be large doses of baking soda in water, soap and water, limewater, or magnesia. The antidote for poison such as lye is vinegar or lemon juice, both diluted with an equal quantity of water, followed by milk or olive oil. If match heads, containing phosphorus, have been swallowed, give an emetic of mustard in water, then magnesia or chalk in milk. The antidote for tincture of iodine is a solution of starch and water. The label on the bottle containing a poison may also name an antidote for it.

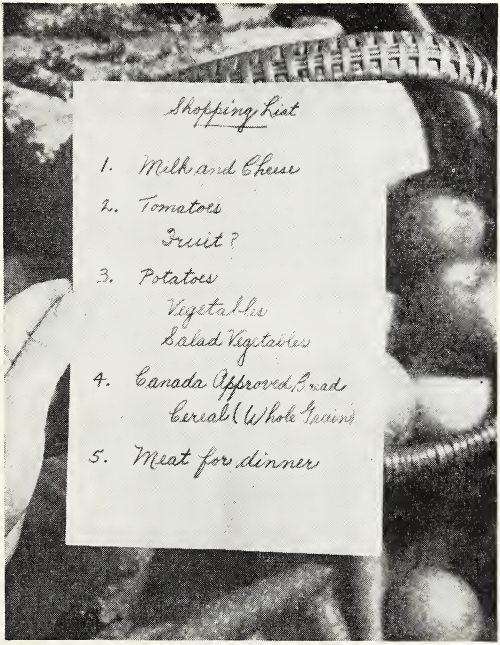
Things To Do

1. Ask your local Medical Officer of Health for a coloured poster illustrating Canada's Food Rules.

2. For your classroom library, write to the Nutrition Division, Department of National Health and Welfare, Ottawa, for a copy of the 52-page booklet entitled "Healthful Eating", and for other literature dealing with food topics.

3. Keep a record of the foods you eat for a week. How closely do you follow Canada's Food Rules?

4. Make charts of foods that provide the vitamins we need.



Shopping List

1. Milk and Cheese
2. Tomatoes
   Fruit?
3. Potatoes
   Vegetables
   Salad Vegetables
4. Canada Approved Bread
   Cereal (Whole Grain)
5. Meat for dinner

FIG. 9-11. A SHOPPING LIST.

(a) Use pictures, drawings, and labels from packages to make a chart of foods rich in vitamin D.

(b) Make similar charts to illustrate foods rich in vitamins A, B, and C.

5. Dramatize a healthful meal. Include the selection and preparation of the food, and the happy incidents connected with the serving and eating of the meal.

6. Make a poster to illustrate one of these topics: *Canada's Food Rules, Children Need Vitamin D, A Healthful School Lunch, Start the Day Right.*

7. Have an excursion to one of the following: a bakery, a flour mill, a grain elevator, a dairy farm, a creamery, a cheese factory, or a packing house.

8. Examine the shopping list shown in fig. 9-11 and decide whether it illustrates Canada's Food Rules.

For Research

1. To learn more about foods, obtain and read publications distributed by the Ontario Inter-Departmental Nutrition Committee, 150 College Street, Toronto 5.

2. Most foods may be described as serving one or more of the following purposes to a high degree: A. provides much starch or sugar; B. provides some fat or oil; C, gives us minerals in important quantities; D. provides useful proteins; E. builds and repairs body tissues; F. supplies us with necessary vitamins; G. serves as a body regulator; H. supplies energy; I. helps to build strong teeth and bones.

In a vertical column, list the foods mentioned below. Investigate their characteristics. Then, after each, write the correct letters, A, B, etc., to indicate the facts listed above which are characteristic of that food.

Foods: rice, beef liver, peanuts, milk, skimmed milk, butter, cheddar cheese, potatoes, green peas, spinach, bacon, cabbage, oranges, custard, whole-wheat bread, oatmeal.

For Class Discussion

1. "All food comes directly or indirectly from green plants."

2. "All energy comes from the sun." Is this true of the energy that keeps us warm? Of the energy that enables us to work and play? Give reasons for your answer.

Test Questions

1. Why do we require more food in winter than in summer?

2. Why should our foods contain more fats in winter than in summer?

3. Why do we need more water in hot weather?

4. Why should every person who is still growing take Vitamin D every day of the year?

5. State the four main purposes served by our food.

6. Name six essential kinds of nutrients found in food.

7. How do these keep food from spoiling: canning food, keeping food very cold, drying food?

◆

Read

Compton's Pictured Encyclopedia: "Our Daily Bread and How It Is Made", Vol. 2, pp. 294-298; "Food", Vol. 5, pp. 210-224; and "Fruits" (many coloured plates), Vol. 5, pp. 303-312.

16 mm. Sound Films

Training Table (colour) (H-25)

Food and Nutrition (HE-6)

Home Canning (HE-7)
Ontario Visual Education Branch.

School Lunches

Vitamin D

What Makes Us Grow?

Your Morning Milk
National Film Board, Ottawa.

Food (with teacher's guide)
Ryerson Film Service, Toronto.

Preserving Foods (black and white, also colour)

Foods That Build Good Health (black and white, also colour)
Associated Screen News Limited, Toronto.

Film Strips

What Breakfast Did for Emily (colour)

A Good Breakfast (colour)

Freezing Fruits and Vegetables

Rural School Lunches

Why We Eat (colour)

Why We Eat—Milk (colour)

Why We Eat—Fruit (colour)

Why We Eat—Vegetables (colour)

Why We Eat—Cereals (colour)

Why We Eat—Meats (colour)
National Film Board, Ottawa.

The Essentials of Diet (colour)

Eat Well! Live Well! (colour)

The Nutrients in Food (colour)
Ryerson Film Service, Toronto.

10

WHAT BECOMES OF OUR FOOD?

EATING IS A PLEASURE; it is also a necessity. Little good comes from the food we eat unless it is digested, that is, made ready for our bodies to use. In this chapter we shall learn how our bodies prepare and use the food we eat.

Our Food Must Be Digested

DIGESTION STARTS IN THE MOUTH. The teeth bite, chew, and crush the food. The front teeth, named incisors, cut the food into pieces. The back teeth, the molars, grind it still finer, helping digestion in the mouth and later in the stomach and intestines. Thorough chewing mixes the food well with the saliva. The more we chew, the better the mixing.

EXPERIMENT 10-1. Why is it necessary for our food to be mixed with saliva?

Put a pinch of starch in each of two test tubes. Add a little water to each. Shake both well. To one add the same amount of saliva as there is water. Shake this again. Test the liquid in both test tubes with iodine. Which contains starch now? What did the saliva do? See fig. 10-1. In the same manner, the saliva in the mouth changes the starch of food into some other substance.

EXPERIMENT 10-2. To what is the starch changed?

Chew a cracker or some wheat kernels. What change in taste takes place between the tenth and the fortieth chew? The sweet taste shows that the saliva changed the starch to sugar.

EXPERIMENT 10-3. Why was it necessary for the starch to be changed to sugar?

Add one-half teaspoonful of starch to a test tube of warm water. Shake it well. Pour the mixture through filter paper. What is left on the filter paper?

Repeat the experiment, using sugar instead of starch. Why is there nothing left on the filter paper? How does starch differ from sugar?

Chewing helps saliva to change the starch in our food to sugar. Because sugar is soluble in water, it is more easily used by the body.

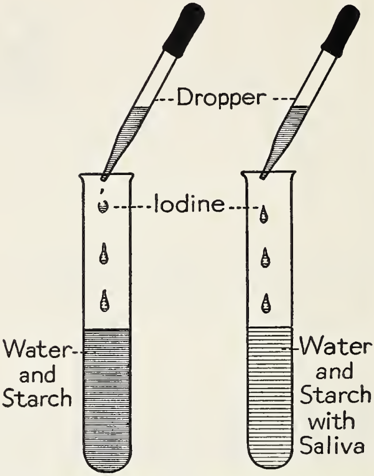


FIG. 10-1. SALIVA HELPS TO DIGEST STARCH.

DIGESTION CONTINUES IN THE STOMACH. When we swallow, our food is passed down a tube from the mouth to the stomach. After a meal, food is stored in the stomach until it is partly digested. This takes from five to seven hours, depending upon the kind of food. Rich pastry and pork take longer than most foods. Muscles in the walls of the stomach work back and forth, up and down, churning the food and mixing it with juices that the stomach supplies. These digestive juices, given out by glands in the walls of the stomach, make the proteins in our food nearly ready for our bodies to use.

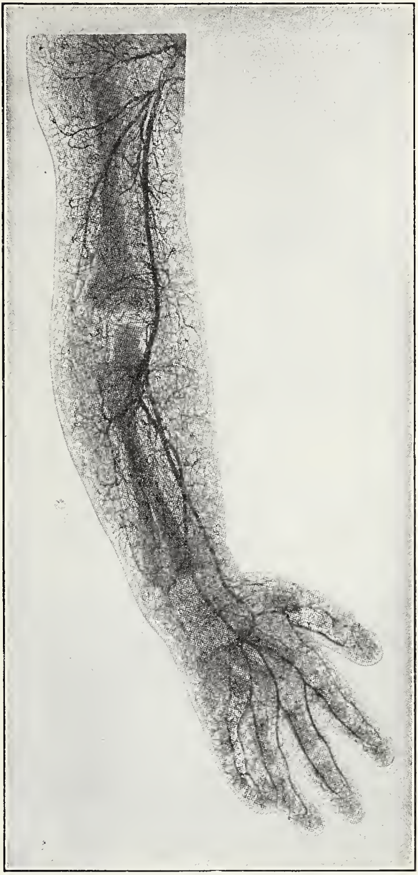
DIGESTION IS COMPLETED IN THE SMALL INTESTINE. As the food in the stomach is changed to a thick liquid, a trap door lets spurts of it into the small intestine. Here, other digestive juices are mixed with the partly digested food. These digest the fats and complete the digestion of the other parts of the food.

The Blood Absorbs Digested Food

The digestive juices in the mouth, the stomach, and the intestines make all parts of our food soluble. Just as the dissolved sugar passed through the filter paper, so our food, when digested, can pass through the walls of the intestines into the blood. The digested food, absorbed in this way by the blood, is ready for use by all parts of the body.

The Blood Transports Digested Food

The blood carries digested food to all parts of the body. Perhaps you have noticed a colourless liquid appear on an injured or scraped part of the skin before it begins to bleed. This watery part of the blood, called *plasma,* absorbs the digested food that passes through the walls of



(After Dr. Eben C. Hill, from "Biology and Human Life", published by Ginn & Co.)

FIG. 10-2. AN X-RAY OF CIRCULATION IN THE ARM.

Numerous fine branches from the arteries (capillaries) carry the blood from the arteries to every part of the body, even to the skin, and then take it to the veins for return to the heart and lungs.

the intestines, then carries it to the bones, muscles, flesh, skin, and nerves. The digested food helps to build and repair all these tissues and to keep the whole body warm and active.

Breathing Uses Food

Our bodies are warm and active. A working engine is warm and active, too, but only so long as it burns fuel. Our bodies use digested food as fuel to produce body warmth and the energy with which we move and work. Breathing makes this possible. Let us discover how.

When we breathe, the air passes through the nostrils, windpipe, and bronchial tubes to our two lungs. These are something like large bunches of grapes, with each grape representing a small air sac, and each little stem representing an air tube leading to an air sac. Each air sac has a thin wall containing fine blood vessels. Through these thin walls the oxygen of the air passes into the blood stream.

To understand how oxygen is transported by the blood, we need to learn about the round, checker-like rafts, called red *corpuscles,* floating in the blood stream (fig. 10-3). These red corpuscles collect oxygen from the lungs and deliver it to all parts of the body. When we know that there are about five million red corpuscles in a drop of blood the size of a pin-head, we realize how tiny and how numerous they must be. Their redness is due to a colouring material called *haemoglobin.* Because haemoglobin cannot be formed without iron, we should eat

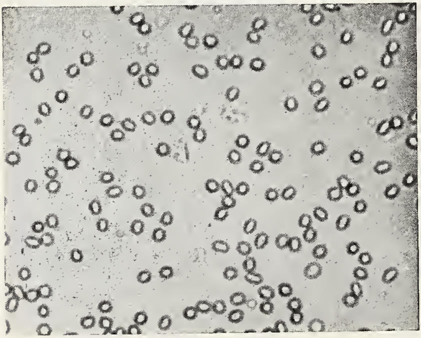


FIG. 10-3. RED BLOOD CORPUSCLES IN A DROP OF BLOOD.

If you were to divide the finest drop of blood into 500 piles and spread one of them out, it would look like this.

some of such foods as egg yolk, red meat, and spinach, all of which contain this mineral.

We see now that the blood transports both digested food and oxygen. When these are brought close together in the blood stream, they combine to produce body heat and the energy we need to work and play.

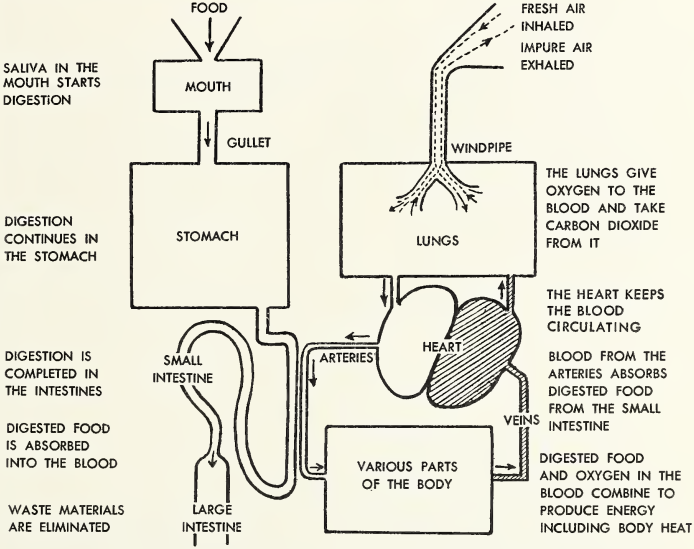

FOOD
FRESH AIR INHALED
IMPURE AIR EXHALED
SALIVA IN THE MOUTH STARTS DIGESTION
MOUTH
GULLET
WINDPIPE
THE LUNGS GIVE OXYGEN TO THE BLOOD AND TAKE CARBON DIOXIDE FROM IT
DIGESTION CONTINUES IN THE STOMACH
STOMACH
LUNGS
THE HEART KEEPS THE BLOOD CIRCULATING
HEART
ARTERIES
SMALL INTESTINE
DIGESTION IS COMPLETED IN THE INTESTINES
BLOOD FROM THE ARTERIES ABSORBS DIGESTED FOOD FROM THE SMALL INTESTINE
VEINS
DIGESTED FOOD IS ABSORBED INTO THE BLOOD
VARIOUS PARTS OF THE BODY
DIGESTED FOOD AND OXYGEN IN THE BLOOD COMBINE TO PRODUCE ENERGY INCLUDING BODY HEAT
WASTE MATERIALS ARE ELIMINATED
LARGE INTESTINE

FIG. 10-4. EATING, BREATHING, AND CIRCULATION ALL WORK TOGETHER FOR OUR GOOD.

Waste Products Are Eliminated

When food is digested and used in our bodies, waste products are left over or produced. The indigestible parts of food are discarded through the intestines. Water from digested food is absorbed into the blood stream. Then it is used to help carry away wastes from other parts of the body.

When digested food and oxygen combine in the blood, carbon dioxide and water are produced as waste products. The blood carries the carbon dioxide and water to the lungs, from which we breathe them out. Other waste products are discarded through the skin (in perspiration) and through the kidneys.

Aids To Digestion

1. Eat only pure food.
2. Drink plenty of water.
3. Eat meals at regular times.
4. Do not overload the stomach.
5. Be cheerful while eating.
6. Chew your food well.
7. Care well for your teeth.
8. Rest after meals.
9. Develop regular habits of elimination.

Review Questions

1. What is meant by digestion?
2. Why must food be digested before it can serve us?
3. In what way does saliva help digestion?
4. A meat sandwich contains starch (in the bread), protein (in the lean meat), and fats (in the butter and fat meat). What parts of the sandwich are digested in the mouth? In the stomach? In the small intestine?
5. In what ways does thorough chewing help digestion in the mouth? In the stomach? In the small intestine?
6. How do these help the body to use food: blood plasma, red corpuscles?
7. What must combine with digested food before it can produce body heat and the energy we need to work and play?
8. What two waste products, produced when the body uses food, are disposed of through the lungs?

◆

16 mm. Sound Films

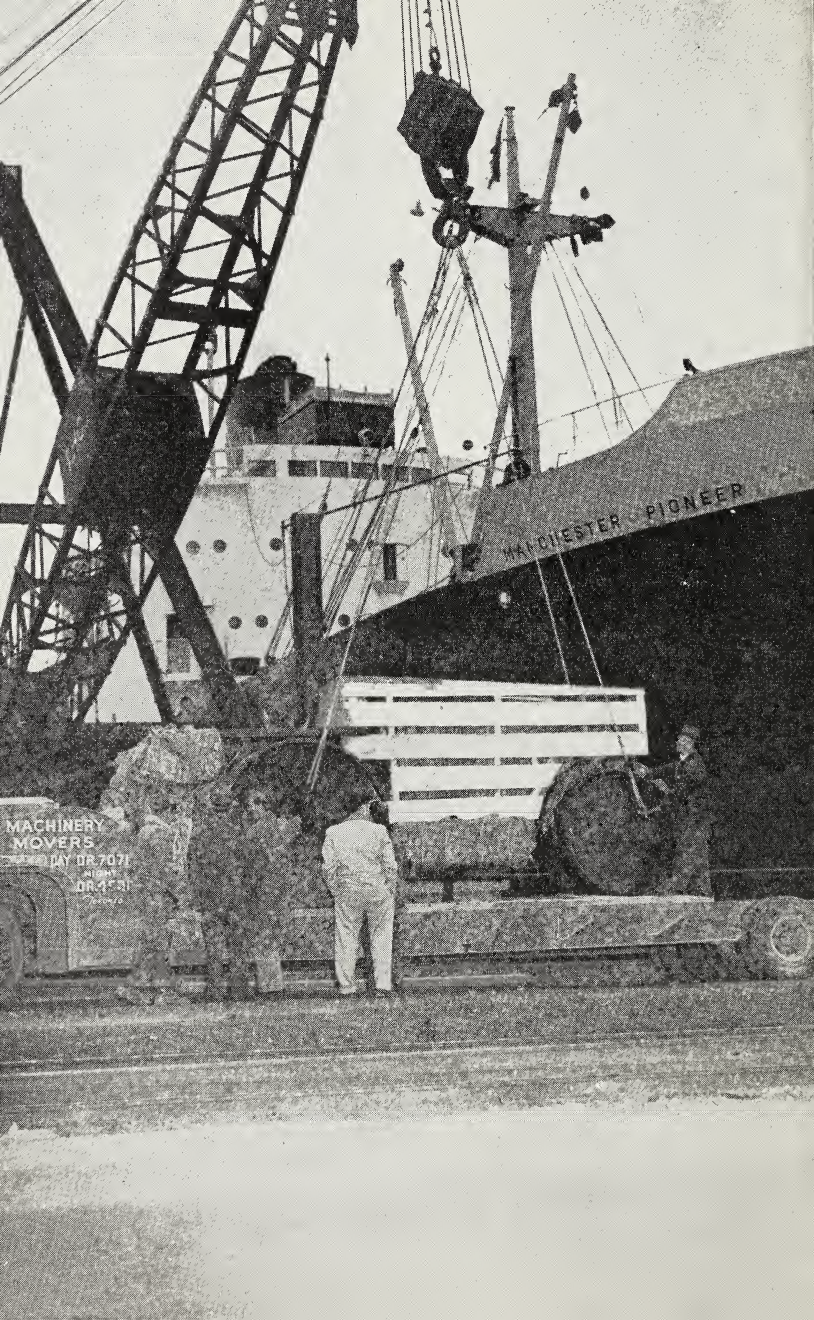
Digestion of Food (H-5)

The Heart and Circulation (H-12)

Elimination (H-30)
Ontario Visual Education Branch.

Film Strips

How food Is Digested (colour)
Ryerson Film Service, Toronto.


MANCHESTER PIONEER
MACHINERY
MOVERS
DAY DR.7071
NIGHT

UNIT FOUR

Energy and Machines

How silent, how uninteresting, how useless to us the world would be if there were no motion, no action, no machines, no energy being used! In this unit we shall find out how magnets and machines work in our interests.

11. *MAGNETS HELP US IN DAILY LIVING*

Magnets serve mankind well. In compasses they have for centuries guided travellers on land and on sea, and now in the air. In telephone and telegraph instruments they enable us to converse with distant people. As a part of generators and electric motors, they help to provide the power so necessary in the modern machine age.

12. *MACHINES MAKE OUR WORK EASIER*

Man has always had to work for a living. Early man did most of his work by hand. Through the centuries new inventions have made possible many devices to help man do his work. These are called machines. Scientists classify simple machines and the working parts of more complex ones as levers, inclined planes, pulleys, and wheels and axles. With the help of various kinds of power—man power, horse power, and electrical power—these machines make man's work easier, enable him to have more conveniences and luxuries, and help him to enjoy life more fully.

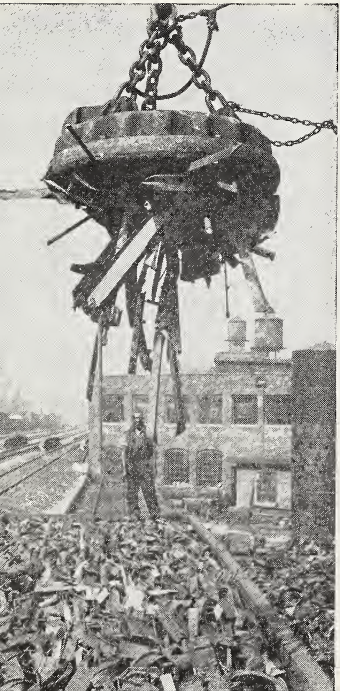
Study the photograph on the opposite page. A large amount of energy is used up by the powerful machines, including the huge crane, as they unload machinery for display at the International Trade Fair at Toronto.

11

MAGNETS HELP US IN DAILY LIVING

Did you ever wonder why a compass needle sets itself in a north-south direction? Have you watched scrap iron being lifted from a truck or a railway car by a large metal disk lowered by a crane until it merely touched the metal? There is no magic about these things. It is as natural that they should happen as that a stone, pulled down by the force of gravity, should fall to earth. The compass needle and the scrap iron were both acted upon by the force of magnetism.

Magnetism has been of interest to people throughout the ages. The early Greeks and Romans knew about it. Perhaps you have used a magnet to "fish from a fish pond" or to find a lost needle. Perhaps you have experimented with magnets just to satisfy your curiosity about how a telephone



(By Ewing Galloway, N.Y.)

Fig. 11-1. A 3,000-Pound Magnet Loading Scrap Iron on a Railway Car in Chicago.

or some other everyday convenience works. Let's find out more about magnetism.

MAGNETS ATTRACT SOME SUBSTANCES. Magnetic and Non-magnetic Substances.

EXPERIMENT 11-1. What kinds of substances do magnets attract?

On a paper, mix nails, pins, coins, pieces of wood, paper fasteners, iron filings or steel wool, and pieces of paper and glass. Try to pick up each kind of material separately with a magnet. What is the material in each article that was picked up?

Magnets will pick up or attract articles made of iron or steel. Therefore, such substances are called *magnetic substances.* Magnets will not attract wood, paper, glass, silver, copper, rubber, or cork. Hence we call these substances *non-magnetic substances.*

Learning About Magnetic Attraction.

EXPERIMENT 11-2. How can we separate iron filings from sand, or nails from sawdust?

Mix some iron filings with sand. Now remove these from it by dragging a magnet through the mixture until no more filings are picked up by the magnet. Use the same method to pick up nails lost in sawdust.

EXPERIMENT 11-3. How far does the attraction of a magnet extend?

On a paper resting on a level table draw a line a foot long. Mark the line in inches. Spread iron filings along it. Place the end of a magnet at the end of the line. Tap the paper gently. In what direction do the iron filings move? How far away does the magnetic attraction extend? How does the strength of attraction of the magnet change with distance?

Repeat the experiment, using a larger, stronger magnet. Does the attraction of a strong magnet extend farther than that of a weak magnet?

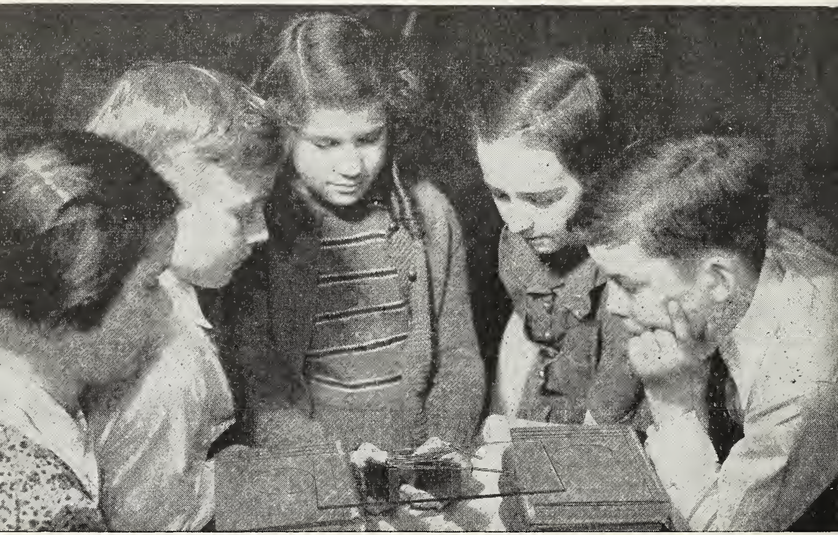
EXPERIMENT 11-4. Does the attraction of a magnet work through other substances?

(a) Spread a few small nails on a table. Lay a piece of paper over them. Hold the end of a magnet above, but close to, the paper.

Does the magnet lift the tacks and paper? Does magnetism work through paper?

(b) Scatter some small tacks on a piece of glass (fig. 11-2). Move a magnet around beneath, but close to, the glass. Do the tacks move? Does magnetism work through glass?

(c) Try to pick up tacks with a magnet wrapped in cloth. Does the force of magnetism pass through cloth?



(*Scott, Foresman & Co.*)

FIG. 11-2. YOU WILL ENJOY EXPERIMENTING WITH MAGNETS.
Will a magnet attract nails through glass?

Magnets attract magnetic substances, even when separated from them by paper, glass, cloth, and other non-magnetic substances. The force of a magnet can pass through materials that the magnet does not attract.

DIFFERENT PARTS OF A MAGNET ATTRACT WITH DIFFERENT STRENGTHS.

EXPERIMENT 11-5. What parts of a magnet are strongest?

(a) Scatter some iron filings, pins, or small nails on a piece of paper. Lay a bar magnet on them. Pick it up. Do the magnetic substances cling to all parts of the magnet? What parts of the magnet pick up the greatest number of objects? See fig. 11-3, A.

(b) Lay a piece of glass on a bar magnet. Sprinkle iron filings on the glass over the magnet. Tap the glass gently. To what parts of the magnet are the greatest number of filings attracted? Why? Compare the numbers attracted to a point two inches from the end of the magnet with the number attracted to a point three inches from the end.

Magnets are strongest at their ends, called their *poles.* The strength of a magnet becomes less and less towards its middle point.

MAGNETS WORK ACCORDING TO A PATTERN. We have learned that the force of a magnet attracts magnetic substances, that this force can work through non-magnetic substances, and that this force decreases from the ends towards the centre of the magnet. Another experiment will show us that the force of a magnet follows a very interesting pattern.

EXPERIMENT 11-6. How does the force of a magnet extend around it?

Repeat experiment 11-5, (b). Watch the little filings of iron move into new positions. Notice the pattern formed by them around the magnet. Draw the magnet, the glass, and the picture made by the filings on the glass.

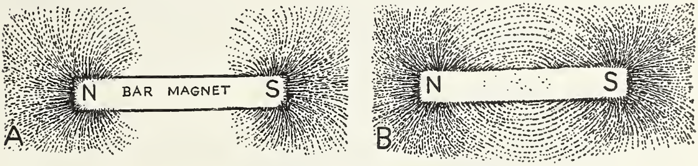


FIG. 11-3. HOW MAGNETS WORK.

A. Magnets are strongest at their poles. B. A bar magnet attracts iron filings according to the pattern shown here.

The magnetic force of the magnet pulled the filings into a definite pattern, as shown in figure 11-3, B. The whole area over which the magnetic force acts is called the *magnetic field* of the magnet. The lines along which the filings arrange themselves are called *magnetic lines of force.*

THERE ARE DIFFERENT KINDS OF MAGNETS. Natural and Artificial Magnets. For centuries men have been familiar with a kind of rock that they called "lodestone" or "leading stone" because it attracted pieces of iron. This is really one kind of iron ore, known as *magnetite.* It is thought that the mineral was named after Magnesia, in Syria, where large natural deposits were found long ago.

A piece of magnetite is a natural magnet (fig. 11-4, A). It attracts iron and steel in the same manner as the magnets we have been using attract them.

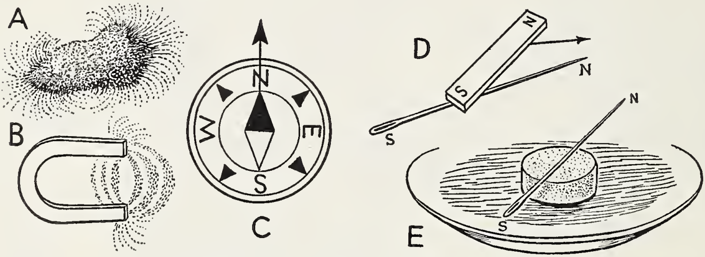


Fig. 11-4. Some Different Kinds of Magnets.
A, lodestone (magnetite), a natural magnet; B, a horseshoe magnet; C, a magnetic compass; D, a needle being magnetized; E, a magnetized needle acting like a compass.

Magnets made by man are called artificial magnets. They may be in the form of a straight bar, or shaped like a horseshoe. The two ends of a horseshoe magnet, like those of a bar magnet, are called poles. See fig. 11-4, B.

The Magnetic Compass. The face of a compass is somewhat like the face or dial of a clock, except that it is marked in directions (north, south, east, and west) instead of in hours. See fig. 11-4, C. The points of a compass needle, unlike the hands of a clock, always point in opposite directions, one north and the other south. To read directions by means of a compass, we turn the compass round until the word "north" lies under the black pointer of the needle. Then the other lines on the compass will point out and name the other directions.

EXPERIMENT 11-7. Make a magnetic compass.

Lay a bar magnet carefully on a large, flat cork on water, or suspend a bar magnet by means of a thread tied around its middle. In what direction does the magnet set itself? Move it until it points in another direction, then release it and observe whether it turns back to the same north-south direction. Repeat this last test several times.

A suspended magnet, or any magnet free to turn, always points north and south. The end or pole that points north is called the *north-seeking pole,* marked "N" on a magnet. The pole that points south is called the *south-seeking pole,* marked "S" on a magnet. We shall speak of them as *north pole* and *south pole* respectively.

Magnets You Can Make

EXPERIMENT 11-8. Change a knife blade into a magnet.

Try to pick up iron filings with your knife blade. If the blade does not pick up the filings, it is not a magnet. Rub the blade lengthwise along a magnet several times—always in the same direction, never back and forth. Now try to pick up iron filings with the blade. If it does so, it is a magnet.

EXPERIMENT 11-9. Make a compass by magnetizing a needle.

Magnetize a needle as you did the knife blade. Lay the magnetized needle horizontally on a floating cork. In what direction does it come to rest? The end pointing north is the north pole of your new compass. See fig. 11-4, D and E.

EXPERIMENT 11-10. How does heat affect the magnetism of a magnet?

While holding your magnetized needle in pliers, heat it intensely. After it cools, test its magnetic power. Is the needle still a magnet?

EXPERIMENT 11-11. Is a broken piece of a magnet also a magnet?

Break a magnetized needle in two. Test each part to find out whether it will still pick up iron filings. If so, each part is a magnet. Will each part of the needle point north and south if placed on a floating cork?

When good steel is magnetized, it holds its magnetism for a considerable period of time. Magnetized iron soon loses its magnetism. Heating a magnet softens the steel in it and causes it to loose its magnetism.

When a magnet is broken, each part becomes a complete magnet in itself, having a north pole and a south pole. This is true because the magnet is made up of a large number of tiny particles, called *molecules,* each of which is a magnet. All of these little molecular magnets point in the same direction as the whole magnet. Therefore, any broken part of a magnet has north and south poles.

MAGNETS OBEY NATURAL LAWS. Magnets Attract and Repel Each Other.

EXPERIMENT 11-12. How do magnets affect each other?

(a) Suspend a bar magnet by means of a thread. Bring the north pole of a second bar magnet near the south pole of the suspended one. What happens? Bring the south pole of the second magnet near the north pole of a compass needle. What happens now?

(b) Bring the north poles of two magnets near each other. How do they affect each other? Bring two south poles near each other. What happens? Now study fig. 11-5.

The north pole of one magnet always attracts the south pole of another magnet. Hence we say "opposite or unlike poles

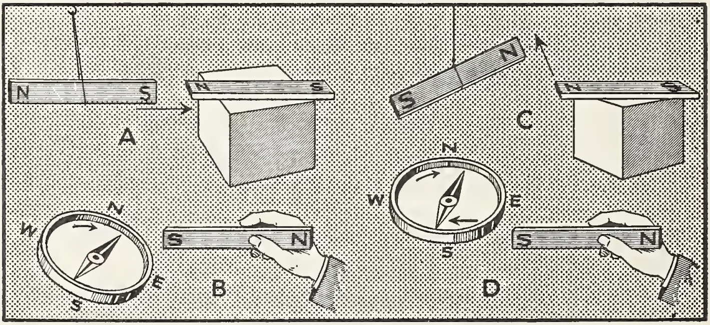


FIG. 11-5. MAGNETS OBEY NATURAL LAWS.

A. The north pole of one magnet attracts the south pole of another magnet. B. The south pole of a magnet attracts the north pole of a compass needle. C. The north pole of one magnet repels the north pole of another magnet. D. The south pole of a magnet repels the south pole of a compass needle.

attract each other". Two north poles or two south poles (like poles) always repel each other. So we say "like magnetic poles repel each other". Magnets always obey this law of magnetism: "unlike or opposite poles of magnets attract each other; like poles repel each other".

The Earth Is a Magnet. Knowing the law of magnetism causes us to wonder why a compass needle always comes to rest in a north-south direction. Scientists have the answer. The earth itself is a magnet. It acts as if a huge bar magnet, nearly 8,000 miles long, extended through it in a north-south direction. The earth has a magnetic pole in the far north, a little way to one side of the real north pole. This magnetic north pole attracts the north-seeking or north pole of any magnet or compass needle. Similarly, the magnetic pole of the earth in the far south attracts the south-seeking or south pole of a magnet or compass.

MAGNETS CAN BE MADE BY ELECTRICITY.

EXPERIMENT 11-13. Make a magnet by using electricity.

Obtain a four-inch nail. Will it pick up tacks? Because it does not, it is not a magnet. Wrap forty to fifty turns of insulated electric wire around the nail; then attach the two ends of the wire to the terminals of a dry cell. Will the nail now pick up tacks? If it does, it is a magnet. Disconnect one end of the wire from the dry cell. Does the nail hold the tacks now? Is it a magnet? Study fig. 11-6.

The nail became a magnet while electricity was passing through the wire coiled around it. It lost its magnetism when

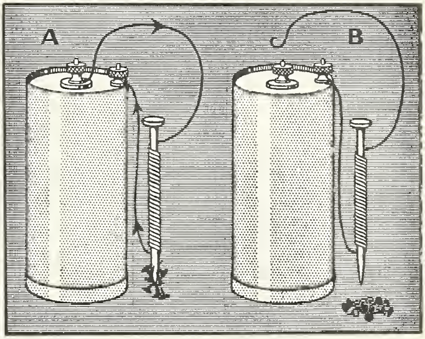


Fig. 11-6. Making an Electromagnet. A. The electric current flowing through the wire changes the nail to a magnet. B. Disconnecting the wire stops the current, and the nail loses its magnetism.

the electric current stopped flowing. A magnet made in this way by electric current is called an *electromagnet*. The strength of an electromagnet is increased by using more coils of wire, or by using a stronger electric current, or by both.

The magnet used by a crane to lift scrap iron from a railway car, or to move it from place to place, is a powerful electromagnet. Now examine fig. 11-1 again.

MAGNETS SERVE US IN MANY WAYS. Magnetic compasses made it possible for Columbus to discover America and for other men to explore the wide expanses of sea and land. Today such compasses help us to find our way by air, land, and water.

Many of our everyday conveniences are made possible by electromagnets. They ring the bells of telephones and electric doorbells; they enable us to send messages by telegraph. Electromagnets make possible the generators and motors upon which we constantly depend for light, power, and transportation.

More Things To Do

1. Test a piece of lodestone to find out whether it has poles like a magnet.
2. Discover whether magnetic force will act through a piece of plastic.
3. Find out where the attraction in a horseshoe magnet is greatest.

Test Yourself

1. Tin is a non-magnetic substance. A tin can is made chiefly of iron, covered with a thin coating of tin to keep it from rusting. Explain why a tin cup can be attracted by a magnet.
2. Tell (a) how to magnetize a knife blade, (b) how to remove the magnetism from the blade.
3. Explain what you understand by: poles of a magnet, magnetic substance, non-magnetic substance, north-seeking pole, south-seeking pole, magnetic field.
4. Give two reasons why a compass needle points in a north-south direction.
5. State the law of magnetism.

Read

Compton's Pictured Encyclopedia: "How We Know Directions and Find Our Way", Vol. 4, pp. 94-101.

16 mm. Sound Films

Magnets (with teacher's guide)
Ryerson Film Service, Toronto.

Magnetism (black and white, also colour)
Associated Screen News Limited, Toronto.

Film Strips

Magnets
Ryerson Film Service, Toronto.

12

MACHINES MAKE OUR WORK EASIER

PERHAPS THIS TITLE makes you think of aeroplanes, automobiles, tractors, combines, cement mixers, elevators, lawn mowers, and sewing machines. Yes, all of these are machines; all of these help to make our work easier. However, there are many very simple devices which we use in everyday living to make our work easier. They are also called machines.

By trying to answer the following questions, you will think of many very simple, but useful, machines.

Some Simple Machines

Which Is Easier?	Why?
1. To pull a nail with the fingers or with a hammer?	The hammer helps us pull the nail: it is a machine.
2. To carry 50 pounds of potatoes or to move them in a wagon or a wheelbarrow?	Wheels make it easier to move loads: they are machines.
3. To squeeze juice from an orange with the hands or with an orange squeezer?	The orange squeezer helps us press the juice from the orange: it is a machine.
4. To lift a 100-pound box up onto a truck, or to slide it up a sloping plank or a ramp?	The sloping plank or ramp makes it easier to raise the weight: each is a machine.

For centuries man has used machines to help him do his work. Those used by primitive man were few in number and very simple. He invented clubs, stone arrowheads, sharpened sticks or spears, a pole to pry up a heavy weight, and simple kinds of wooden ploughs. The builders of the great pyramids of Egypt probably moved the massive blocks of stone up long sloping surfaces rather than attempt to lift such huge weights. Centuries ago men learned to use rollers or wheels to move heavy loads. Man has always tried to find ways of making his work easier. As a result, he has invented new kinds of machines from time to time. Civilization and the use of machines have progressed together. Now, in our modern Machine Age, man is constantly inventing new machines and new ways of combining and using older kinds of machines.

To the scientist, a machine is anything that helps us to do work. We should ask, "What does a scientist mean by the word *work?*" An illustration will answer the question. Suppose you stand and hold up a 10-pound weight for a while. That is *not* work. You are merely supplying an upward force of 10 pounds. Now lift the weight a foot. You moved the object through a distance of one foot by using the force of 10 pounds. This is work. Work is measured in terms of the weight of the object and the distance it is moved. Lifting a weight of one pound for a distance of one foot employs one foot-pound of work. To lift 10 pounds a distance of two feet requires 20 foot-pounds of work. A 100-pound person does 1,000 foot-pounds of work when he moves his own 100 pounds up a ladder or a stairway 10 feet high.

Kinds of Machines

Machines help us to do work, i.e., they help us to move things. Knives, forks, and spoons are machines; baseball bats and door knobs are machines; so are keys and screwdrivers, bicycles and aeroplanes. All of these machines belong to one of four main classes of simple machines, or are a combination of two or more kinds of such simple machines. These four classes are called levers, inclined planes, pulleys, and wheels and axles.

LEVERS. A teeter-totter is a lever. So is a pole when used to pry up a heavy weight. Figure 12-1 and the experiment below show how a lever works.

EXPERIMENT 12-1. How can we make a 10-pound weight lift a 20-pound weight?

Balance a board six feet long over a narrow support, called the *fulcrum.* Place a 20-pound weight on one end of the board and a 10-pound weight on the other end. Move the board back and forth on the fulcrum until the two weights balance each other. Measure the distance from the centre of each weight to the part of the board directly over the fulcrum.

When you balanced the board, you used it as a lever. The 20-pound weight should be only half as far from the fulcrum as the 10-pound weight is from the fulcrum. The product of the heavy weight and its distance from the fulcrum should be equal to the product of the light weight and its distance from the fulcrum. This is always true of levers.

Now study fig. 12-1, A and B.

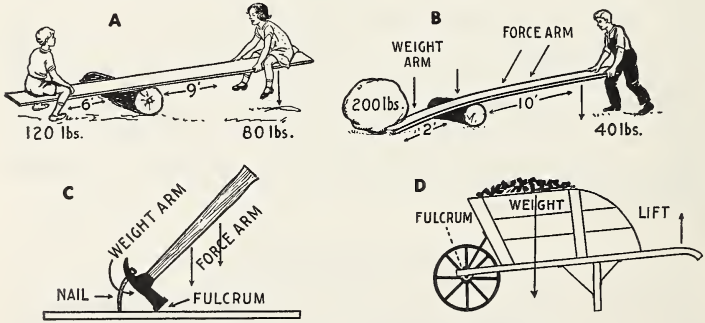


FIG. 12-1. FOUR EXAMPLES OF LEVERS.

A. A teeter-totter. How do the weights of the children and their distances from the log (fulcrum) compare? B. Why can the man pry up 200 lbs. by pushing on the plank with a pressure of only 40 lbs.? C. Pressure on the handle of the hammer (the force arm) causes the claws at the end of the weight arm to exert much greater pressure on the head of the nail. Why? D. the wheel of the wheelbarrow supports about two-thirds of the weight of the load; the person lifts the other third only.

A hammer is a lever. See fig. 12-1, C. The fulcrum is the place where the head touches the wood when a nail is being pulled. The *force arm* is the handle; the *weight arm* is the length of the claws to the point where they grip the nail.

A wheelbarrow is a form of lever. See fig. 12-1, D. The fulcrum is at the axle of the wheel. The weight to be moved is placed as close to the wheel as possible. We lift the weight by applying an upward force (lift) at the ends of the handles. If the distance from the axle of the wheel (the fulcrum) to the hands is three times that from the fulcrum to the middle of the load, a lift of 100 pounds on the handles will pick up 300 pounds on the wheelbarrow. Because a wheelbarrow makes work easier, it is called a machine.

Other examples of levers are scissors, crowbars, snow shovels, nutcrackers, brooms, cranes, and our own arms.

INCLINED PLANES. We do not know how the Egyptians lifted the huge blocks of stone when building the pyramids, but we believe they moved them up long slopes like the long ramps leading into a sports stadium or from one floor to another in large garages. In science, we call these sloping surfaces *inclined planes*. These help truckers to load pianos and other heavy objects. We can find out for ourselves how inclined planes, which are really simple machines, make our work easier.

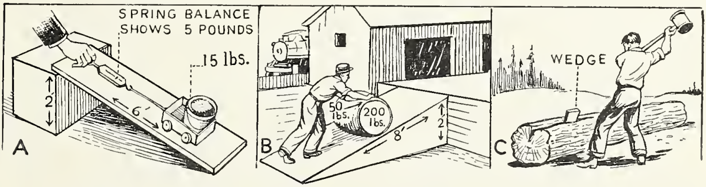


Fig. 12-2. Three Examples of Inclined Planes.

A. Because the plank is three times as long as the box is high, the person can draw up the weight of 15 lbs. by a pull of only 5 lbs. B. How does this inclined plane lighten the work of rolling the barrel up to the platform? C. Because a wedge is tapered, it acts like two small inclined planes and can be driven into the log more easily.

EXPERIMENT 12-2. How does an inclined plane make work easier?

Rest one end of a plank on a chair and the other end on the floor. Place a weight of 15 pounds in a toy wagon. Use a spring balance attached to a rope to pull the wagon up the plank. How does the weight shown by the spring balance compare with the weight of the wagon and its load? Now study fig. 12-2, A.

Many everyday conveniences are helpful to us because they are really inclined planes. A ramp helps us to roll a heavy barrel onto a truck or a platform (fig. 12-2, B). A wedge, used to split wood, is tapered, making it an inclined plane (fig. 12-2, C). Chisels and knife blades are inclined planes. Roadways are often built winding back and forth across a steep hill so that the inclined planes they make will be less steep and, therefore, will make it easier for us to take up heavy loads.

PULLEYS. Pulleys have been used by man for centuries. The ancient Greeks knew how to use them to advantage. Farmers use pulleys and ropes to lift loads of hay into barns. A window is more easily lifted when it has ropes, pulleys, and weights.

We need to know exactly how to arrange pulleys and ropes if we are to derive the full benefit from their use. Fig. 12-3, A shows how a rope and a single fixed pulley help us to lift a weight some distance above our heads. This arrangement does not enable us to lift a heavier weight than we could lift without

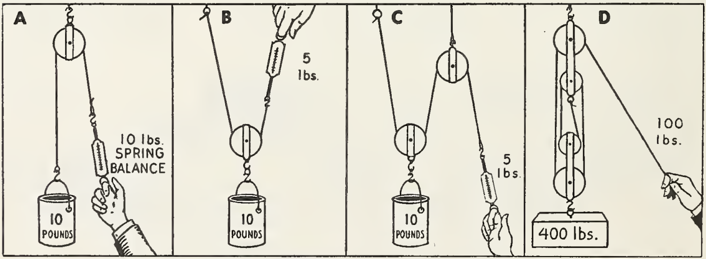


FIG. 12-3. FOUR WAYS OF USING PULLEYS.

A. A single fixed pulley. B. A single movable pulley, as shown here, makes it easier to lift a weight. C. What are the advantages of using a movable pulley (next to the pail) and a fixed pulley to lift a weight? D. A block and tackle, a combination of several pulleys, used to lift heavy weights.

the help of the pulley and rope. The pulleys and ropes of a window are of this type, but the weights make it easier for us to lift the window.

EXPERIMENT 12-3. How much force is needed to lift a 10-pound weight supported by a movable pulley?

Attach a rope to the ceiling or the wall; thread the rope through a pulley; then tie the rope to a spring balance as shown in fig. 12-3, B. Hang a 10-pound weight on the pulley. How many pounds are indicated on the spring balance?

A movable pulley, arranged in this manner, enables us to lift a weight by using only half the force needed to lift it by hand.

Several pulleys can be arranged and connected by ropes so that a very heavy weight can be lifted by a comparatively small force. When we use two pairs of pulleys, as shown in fig. 12-3, D, we call the arrangement a block and tackle. Pulleys arranged in this way are used to lift a piano to the second story of a house or a steel beam into place in a bridge or a building.

THE WHEEL AND AXLE. Primitive man did not know about wheels. He dragged heavy loads along the ground as we drag sleds or toboggans, although a roller, a simple wheel, would have made his work much lighter. Think of the great difference in man's work when he discovered how to construct the wheel, and gradually learned ways of adapting it to his service. Any wheel or combination of wheels is a machine.

Although most wheels turn on an axle, as pulleys do, the rear wheels of an automobile are fixed to the axle, and both turn together. This combination is called a wheel and axle. Other examples of a wheel and axle are: door knob, grindstone, clothes wringer, lathe, the steering wheel of an automobile, and the sprocket wheels on a bicycle.

A windlass shows how a wheel and axle works. See fig. 12-4. A small force on the wheel will lift a heavy weight attached to the rope around the axle. Similarly, a small force on the knob of a door causes a much bigger force on the axle. Thus a wheel and axle act like a lever and make it easier for us to move things. A slight pressure on the large steering wheel of an automobile turns the axle in its centre, and this axle turns the front wheels of the automobile.

Gears are special kinds of wheels and axles in which one wheel causes one or more other wheels to turn. Gears drive clocks, automobiles, bicycles, and other complex machines.

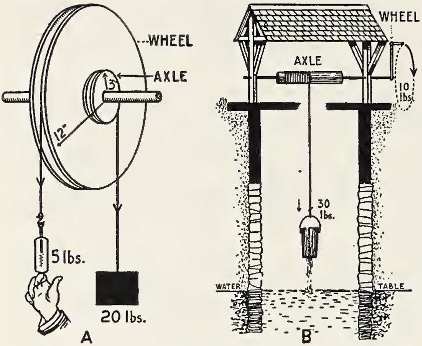


Fig. 12-4. A Wheel and Axle Makes It Easier To Lift a Weight.

A. The pull of 5 lbs. lifts the weight of 20 lbs. because the radius of the wheel is four times that of the axle. B. Why does this windlass make it easy to lift the pail of water from the well?

Learning what makes a bicycle go will help us to understand more about gears. When we push on the pedals, we turn the axle of a large sprocket wheel. This axle turns the large sprocket wheel itself. The teeth on the wheel make the chain turn the rear sprocket wheel, its axle, and the rear wheel. The more teeth there are on the large sprocket wheel in proportion to the number on the rear sprocket wheel, the faster the rider can make the bicycle go, but the harder he has to push on the pedals.

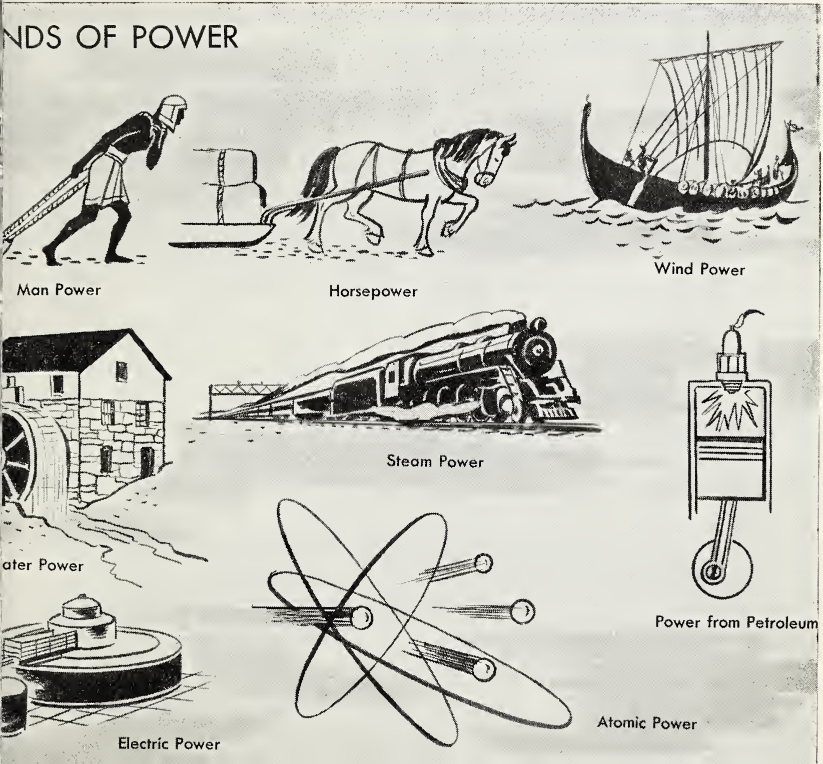
Working with Machines

WHAT MAKES OUR MACHINES HELP US? Machines make our work easier, but they cannot do the work for us. An inclined plane does not lift a weight, neither do the sprocket wheels and chain of a bicycle make the bicycle go. Like all machines, they must have some force supplied to them before they can help do any work.

The forces needed by machines to help us do the work are provided in several ways. Our muscles make it possible for an axe or wheelbarrow to help us. The pressure of wind enables windmills to grind grain. The power of falling water enables water wheels to make electricity. The force of exploding gasoline and the pressure of steam cause engines to run, enabling them to operate bigger machines. Electricity makes it possible for electric motors to operate electric clocks and refrigerators. Our machines would be useless without people, wind, water, gasoline, and electricity to provide the force needed by them to make our work easier.

Fig. 12-5.

(From the WORLD BOOK ENCYCLOPEDIA, copyrighted by Field Enterprises, Inc. Reproduced by special permission.)



FRICTION IN MACHINES.

EXPERIMENT 12-4. What is friction?

Try to slide on hard ground as you would on ice. Try to move a heavy box over a rough floor, then over a smooth or waxed floor. Slide a heavy piece of smooth iron over another piece of iron, first without oil between the two surfaces, then with some oil or grease between them. Press your hands together and rub them back and forth vigorously.

Under which conditions did the objects move more easily, over rough, or over smooth surfaces? With or without oil? How did the rubbing of your hands change their temperature?

Something seemed to make it difficult for you to slide the sole of your shoe, the box, and the piece of iron over the surfaces beneath them. This resistance to motion is called *friction.* Friction often causes heat, as it did between your two hands. Friction is less between smooth or polished surfaces than between rough ones. Oil, grease, and soap make surfaces smooth and reduce friction.

Friction is often harmful. When there is no oil between a wheel and the axle on which it turns, friction wears the rubbing surfaces, makes the wheel turn with difficulty, and may cause the metals in contact with each other to become hot and expand until the wheel fits the axle too tightly to turn on it. For these reasons, all moving parts of machines should be kept oiled to prevent friction and to keep them from wearing. Roller bearings and ball bearings in machines help in a similar manner.

Friction is frequently useful. Walking without friction between the shoes and the surface on which we walk would be as difficult as walking on ice. The friction between tires and road enables automobiles to move forward. Friction causes the brakes of an automobile to stop the wheels turning; it also enables the tires to bring the car to a stop.

SAFETY FIRST WITH MACHINES. The characteristics which make machines useful to us may also make them dangerous. Therefore, safety precautions should be taken in using any machine. To avoid being accidentally cut while using such sharp-edged tools (machines) as knives and chisels, one should always cut away from, never towards, oneself. Turning wheels and gears, running belts, and the various moving parts of machines are constant hazards. Loose clothing and hanging sleeves may become caught in these and cause serious bodily injuries. The moving parts of such hazardous machines should be covered with guards wherever possible. Workmen should refrain from wearing clothing likely to catch in machines, and should always be on the alert to avoid accidents.

Tools and machines should never be left lying where they may cause accidents by tripping or by cutting passers-by. They are especially dangerous if left on stairs or in poorly lighted hallways. Tools and machines should always be put back in their right places as soon as we are finished with them. All should be stored with sharp edges or points away from anyone approaching them.

A minute of carefulness around machines may save a month of pain and unemployment.

Machines Improve Our Way of Living

Civilization has advanced as man has invented new kinds of machines and put them to good uses. The invention and the use of machines are so characteristic of our times that we speak of living in the Machine Age.

Machines have made it easier and easier for people to earn a living and to enjoy life. Tractors and combines have reduced greatly the labour of cultivating fields and harvesting grain. Steam shovels, bulldozers, and dump trucks have replaced much of the hard hand labour in construction industries. Washing machines, dishwashers, vacuum cleaners, and polishers have removed much of the drudgery from housekeeping. As machine work has replaced hand work, wages and standards of living have reached higher levels.

By using machines, a few people can do the work done formerly by many people using hand methods. We might think this would cause unemployment. This seldom happens, for more men are employed making the machines themselves, supplying raw materials for them, and transporting and marketing the increased flow of products.

Machines make it possible to produce more goods and to make them at lower costs. Modern machines on farms increase the amount of grain, milk, and meat produced by each farm worker. As a result, fewer farm workers are needed. If the labour of more men were required to produce the food we get from farms, naturally we would have to pay more for it.

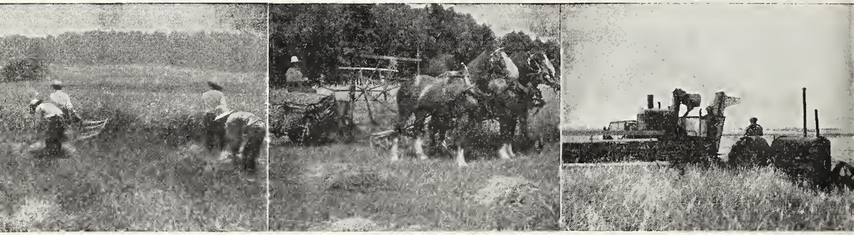


FIG. 12-6. MACHINES HAVE DISPLACED LABOUR BY MAN AND BEAST.

Left: cutting wheat with a cradle and binding it into sheaves by hand half a century ago; *centre:* cutting oats with a horse-drawn binder; *right:* using a modern tractor-drawn combine to cut and thresh grain at the same time.

Imagine trying to make an automobile, a refrigerator, or a book without modern machinery to turn out sheets of metal, parts of motors, and printed pages by the thousands! "An average worker in the United States may produce thirty times as much as an average worker in China where hand methods are used."[1] Without up-to-date machinery, we would not only have to do without many of our everyday conveniences, we would have to pay more for what we have.

Machines have given us more leisure time. The working day is much shorter now than a generation ago, and we have more holidays. This is true because today's machinery makes it possible to produce all the goods we need with fewer hours of labour.

---

[1] Compton's Pictured Encyclopedia.

Leisure time gives opportunities to improve our ways of living. Machines enable us to have more and better things which we can enjoy in our leisure time. Think of automobiles, bicycles, cameras, sporting goods, and books, all of which are made by modern machines. Shorter hours of work leave longer hours for reading, sports, hobbies, and other forms of healthful recreation. Such leisure-time activities make it easier for us to understand other people, at home and abroad.

The Machine Age can be the Golden Age—to make it so is the challenge of our times.

Things To Do

1. Search your school and your home for tools and machines that may cause accidents if improperly used or stored. For each, find out: what danger it presents; how this danger may be prevented or reduced; and whether all possible precautions are being taken to guarantee safety.
2. Examine an automobile, a tractor, a bicycle, or a washing machine, and list as many parts as you can find to illustrate each of these: lever, wheel and axle, danger points, places where friction is undesirable, places where friction is useful.
3. Examine the working parts of a discarded alarm clock to see how the gear wheels move each other and the hands. When two gear wheels move each other, which wheel turns more often, the one with the fewer or the one with the greater number of teeth?

For Discussion

1. Is the invention of new labour-saving machinery more likely to cause unemployment or to create new and better positions for people?
2. How have machines made our ways of living today different from those at the time of our grandparents?

For Written Answers

1. What machines in your home stop working when the electric power goes off?

2. A 12-foot plank rests across a rail fence. Tom (weight, 120 pounds) sits on the plank four feet from the rail. How far from the rail, on the other end of the plank, must Arthur (weight, 80 pounds) sit to balance Tom?

3. Name one kind of machine which helps us to: (a) lift a heavy stove to a second-storey window; (b) pry up an automobile stuck in mud; (c) grind an axe or a knife; (d) lift windows easily; (e) move a heavy box up verandah steps; and (f) split wood. Classify each as a lever, an inclined plane, a pulley, or a wheel and axle.

Read

Compton's Pictured Encyclopedia: "Six Principles That Rule All Machines", Vol. 9, pp. 159-162.

16 mm. Sound Films

Safe Use of Tools (H-19)
Simple Machines (V-9)
Transfer of Power (SG-25)
Safety in the Home (H-20)
Safe Living at School (H-34)
Ontario Visual Education Branch.

How We Get Our Power (with teacher's guide) (SG-36)
Ontario Visual Education Branch; also Ryerson Film Service, Toronto.

Accidents Don't Happen
National Film Board, Ottawa

Machines Do Work (with teacher's guide)
Friction (with teacher's guide)
Ryerson Film Service, Toronto

Safe Living at School (black and white, also colour)
Associated Screen News Limited, Toronto

Film Strips

Living in a Machine Age
Pulleys Make Work Easier
Simple Machines (colour)
Ryerson Film Service, Toronto

UNIT FIVE

Rocks and Minerals Are Important to Man

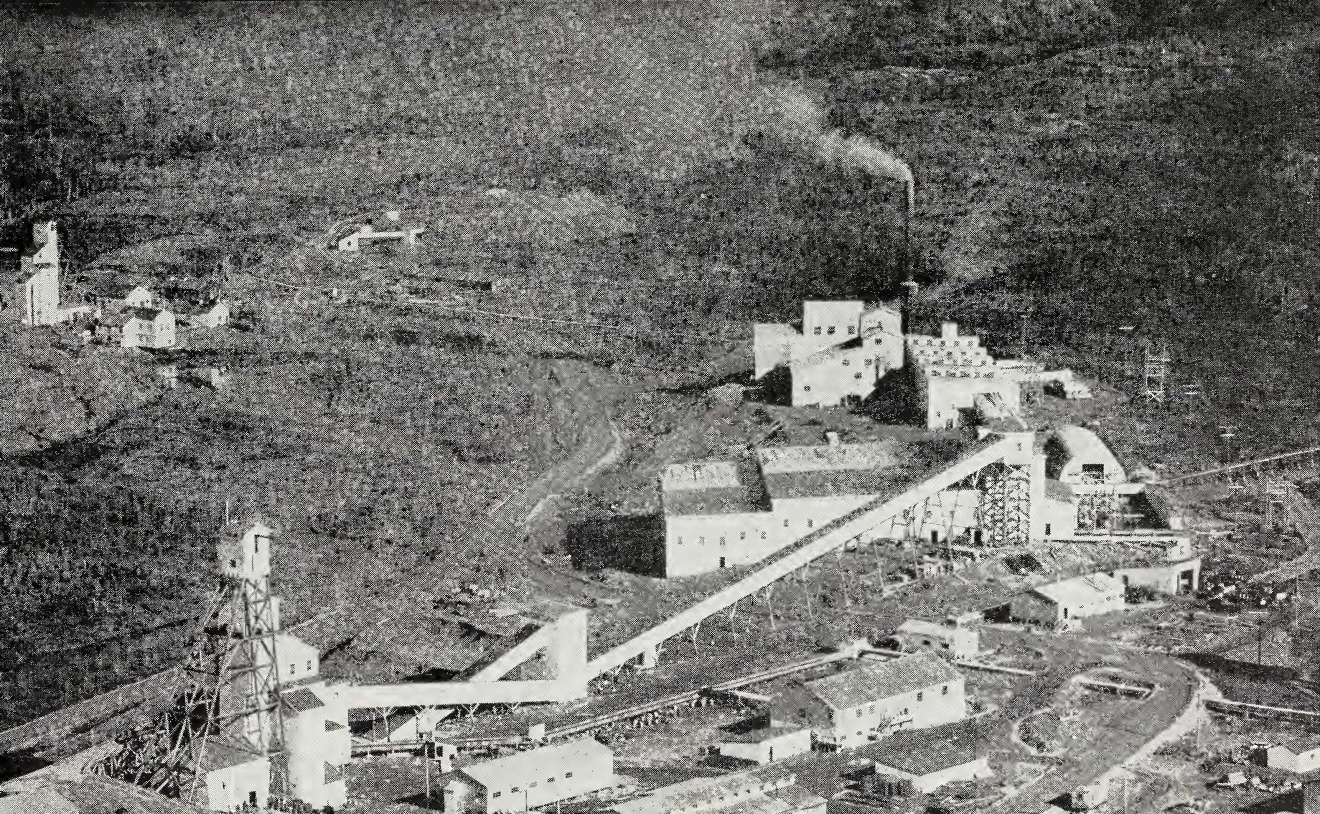
13. *THE EARTH'S CRUST*

Since its beginning, the earth has hidden from the searching eyes of man many of its secrets. How did it begin? What caused the mountains and the valleys, the rivers and the deserts, the changes in climate, in plants, in animals? Partial answers to some of these questions have been discovered by scientists and are given in this chapter. The answers to more questions will be found by other scientists of today or tomorrow, perhaps by yourself. To make such new discoveries we must learn well the lessons of the past.

14. *ROCKS AND MINERALS IN MAN'S SERVICE*

Rocks, minerals, and metals have always played a large part in the world's progress, but never more so than in the present, whether we think of our time as the machine age or the atomic age. These products of the earth make possible skyscrapers and highways, powerful machines and delicate timepieces, the implements of progress in time of peace and of destruction in time of war. As we read this chapter, we will discover some of the ways in which man uses rocks and minerals in daily living, how he extracts precious metals from rock-borne ores, and the importance of the mining industry to all of us.

The accompanying photograph illustrates how the finding of minerals and the opening of a mine leads to the construction of mining buildings and homes, changing a desolate wilderness into an important mining town.



13

THE EARTH'S CRUST

There rolls the deep where grew the tree.
O Earth, what changes thou hast seen!
There where the long street roars, hath been
The stillness of the central sea.
The hills are shadows, and they flow
From form to form, and nothing stands;
They melt like mist, the solid lands;
Like clouds they shape themselves and go.

TENNYSON—*In Memoriam*

EVERYWHERE MAN'S ACTIVITIES depend to a large extent upon the earth's crust and its treasures. In rocky areas man engages in mining to obtain minerals and metals. To make these useful to him, he builds and operates smelters, refineries, and many kinds of manufacturing plants. Where the soil is fertile and the surface level enough to make cultivation easy, man makes a living by agriculture. Where the soil and surface are unsuited to farming, but do enable trees to grow well, he engages in forestry. These three primary industries, mining, agriculture, and forestry, make possible manufacturing, transportation, wholesale and retail marketing, and most of the other occupations through which man makes a living. Yes, the earth's crust and its minerals and soil play a large part in shaping man's ways of living.

The Earth's Origin

Have you ever wondered how the earth on which we live originated? Many men and women have puzzled over this problem and have spent much time in searching for an answer. Many answers have been suggested; none has been found that can be proved correct. In our generation, scientists are still searching for the answer to the question. Tirelessly, they gather together all the information they can discover. They have reached some conclusions which seem reasonable, and which will be interesting for us to consider.

Evidence leads us to conclude that the earth began as a part of the sun. Scientists know that great streamers of gas often shoot out from the sun for thousands of miles. They believe that many millions of years ago a large mass of this gas became separated from the sun while it was moving rapidly through space, as it still does. They are convinced that this huge mass of gas kept turning round on its axis, always moving forwards around the sun itself, just as the earth does today. As the mass of gases—the young earth—moved forwards, some of them cooled and formed a liquid. This was molten rock. Being heavier than the gases, this molten rock would sink to the centre of the earth. Gradually the whole earth became liquid rock. Later the rock changed from liquid to solid, as we think it is today.

We have every reason to believe that the interior of the earth today is very hot. The hot water from geysers, the molten lava from volcanoes, and the increasing temperature as we go deeper and deeper in mines, all lead to this conclusion.

Most scientists believe that the central core of the earth is a solid ball of metal, chiefly iron and nickel, and that its outer crust is made up of ordinary rock, as we know it. Between the central core and the outer crust there is probably a layer of iron and other minerals so hot that they are soft or almost molten, always ready to change to liquid and flow out when any break in the earth's crust reduces the pressure on them. Study fig. 13-1.

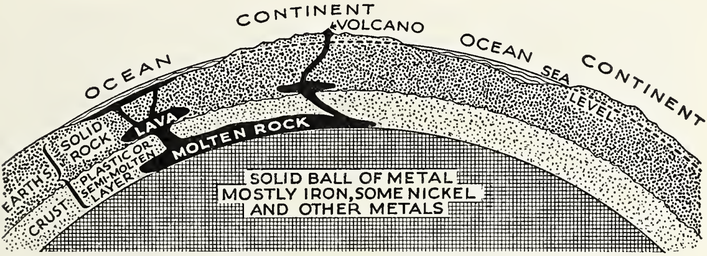

CONTINENT
VOLCANO
OCEAN
OCEAN
SEA LEVEL
CONTINENT
SOLID ROCK
LAVA
MOLTEN ROCK
PLASTIC OR SEMI-MOLTEN LAYER
EARTH'S CRUST
SOLID BALL OF METAL MOSTLY IRON, SOME NICKEL AND OTHER METALS

FIG. 13-1. WHAT OUR EARTH IS LIKE.

Find the continents and oceans shown on this drawing. Describe the two layers that make up the earth's crust. What is the nature of the centre of the earth? In which part of the earth does the molten rock (lava) that flows forth from volcanoes originate? How does it get through to the earth's surface?

Great changes must have followed the formation of the earth and the hardening of its crust. In some manner water formed. This would become clouds, then rain, then streams of water, then oceans. Erosion by falling rain and running water could well have begun the long ages of changes on the earth's surface, and the formation of soil. Then came the plants and animals that inhabit the earth.

The Changing Earth

CHANGING LANDS AND WATERS. Today we think of the earth as made up of continents, islands, and oceans. We have accurate maps to show their shapes and sizes. Some maps that were made many years ago show land where there is water today, and water where there is land now. Since those maps were made, the earth's surface has risen in some places and sunk in others. The finding of paved streets under the sea south of Sweden shows that the land there has, through the years, been gradually sinking.

In some places, lakes and seas of millions of years ago have been filled gradually to form marshes, then dry land. Elsewhere, new lakes and seas have come into being. Probably the earth's surface will always continue to change; maps, too, will continue to change.

We do not know just how the earth's surface came to have the low places that are covered by the seas, the level plains, the rolling plateaus, and the mountain ridges and peaks. We know that, in some way, the crust of the earth must have been pushed up from within to form the mountains. Volcanoes prove to us that pressures that could do this still exist under some parts of the earth's surface. When water formed on the earth's surface, it filled the lowest parts and formed the seas and oceans.

From the time it came into being, the land part of the earth's surface has been changing constantly. It is changing now. Probably it will always keep changing. Waves gradually wear away seacoasts (fig. 13-2). Rain and running water are constantly wearing away some of the exposed rock. When pieces of rock are carried along by running water, the wearing away takes place faster. Thus, high mountain ranges gradually become changed to rolling plateaus, such as the Laurentian Plateau. Running waters form creeks, then rivers. These wear away both their beds and shores, gradually forming deep gorges like

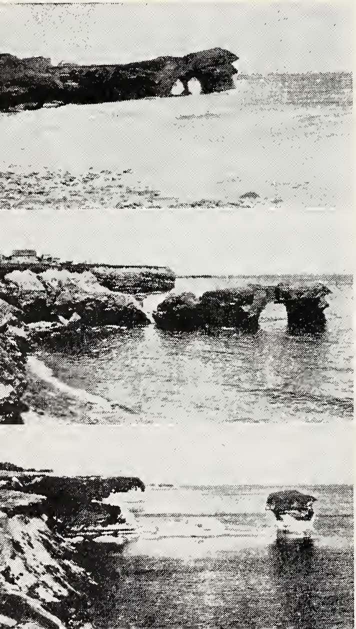


Fig. 13-2. The Water in Waves and Tides Wears Down Coastal Rocks.

Three stages in the wearing away of rock projecting into the Atlantic Ocean. The photographs were taken in 1916, 1918, and 1921.

those of the Niagara and Fraser Rivers, or wide river valleys such as that of the Saint John River in New Brunswick.

Rivers carry millions of tons of pulverized rock material or soil out to the sea every year. When a river merges with the ocean water and loses its speed, it drops its load of sediment. Thus thousands of acres of new land are built up in the form of deltas, like those at the mouth of the Mississippi River.

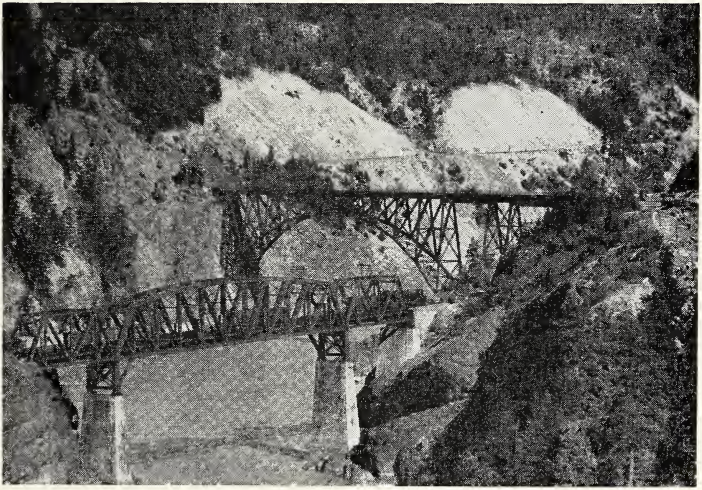


FIG. 13-3. THE FRASER RIVER GORGE.

Here, near Lytton, B.C., the Canadian National and Canadian Pacific railways cross the Fraser River along the picturesque Cariboo highway. Notice the enormous depth of the gorge and how one railway crosses over the other.

PUPIL INVESTIGATIONS. How is the earth around you changing?

Collect and display pictures, or make a scrapbook of clippings from newspapers and magazines, to show changes in the earth's surface in your community. Investigate mountains, mountain streams, landslides, river gorges, glaciers, eroded hillsides, gullies, deposits of sediment, sand banks, soil blown over roadways and fences, and other changing surface features.

Ask elderly people how some of these surface features have changed during their lifetime.

Such investigations show us how changes in the earth's surface are taking place today, and what changes have taken place in recent years. Scientists use such observations of today's happenings to help them judge what changes must have taken place in ages past, and how these changes may have occurred. When they see ripple marks in rocks (fig. 13-4), resembling those visible on a sandy beach today, they conclude that those rocks must have been part of a seashore thousands of years ago. By measuring the rate at which the rock at the crest of Niagara Falls has been worn back in recent years, scientists have concluded that the river must have taken something like 20,000 to 30,000 years to wear the rock back from Queenston and form the Niagara Gorge. Scientists believe this wearing away of the rock by the Niagara River began at the end of the Ice Age. Therefore, this tells us how long ago the Ice Age ended.

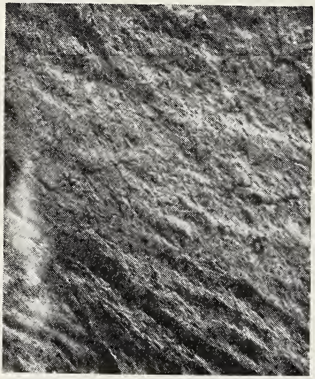


Fig. 13-4. Ripple Marks on Limestone near Banff, Alta. These must have been formed under water millions of years ago.

Other forces in nature are constantly changing the earth's surface. Wind plays its part. In dry areas it blows fertile topsoil from cultivated fields. Along the shores of Lake Erie it has drifted sand into sand dunes high enough to bury trees.

Mountain glaciers, some more than a thousand feet thick, are constantly pushing away or rounding off mountain crags, gouging out valleys, and depositing rocks and soil where the ice melts. In a similar manner the great Canadian glaciers of the Ice Age left the rocky areas of Northern Ontario and the rolling agricultural lands of Southern Ontario somewhat as we find them today.

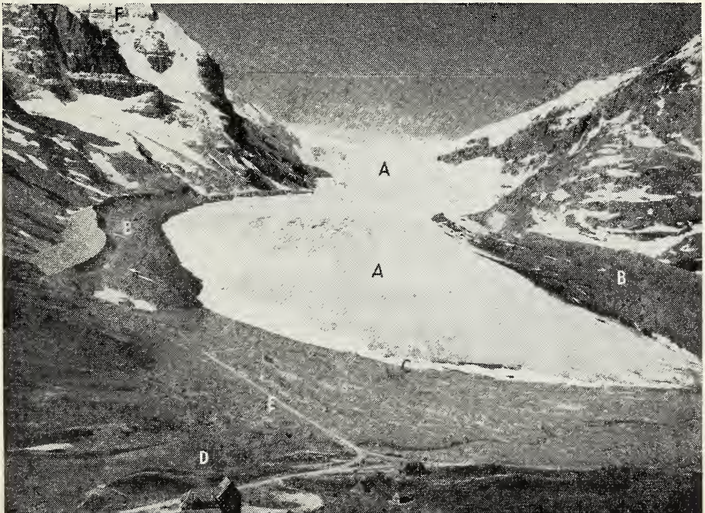
Volcanoes erupt when an opening in the earth's surface enables molten rock to pour out from under the earth's crust. In some places the melted rock, called lava, flows out and hardens in a layer of rock over the earth's surface, or builds a cone-shaped mountain around the outlet of the volcano. Elsewhere the molten rock is blown out as fine volcanic dust which buries everything nearby.

Living things play a part in the changes of the earth's surface. Forests and grass protect the land from being weathered and eroded, but the roots of trees may, at the same time, pry rocks apart or produce chemicals which dissolve some substances from rocks. Animals burrowing in cliffs cause them to tumble. Earthworms loosen and enrich agricultural soil. Man is constantly changing the earth's surface by digging canals, cutting tunnels and passes through mountains, building dams

---

FIG. 13-5. ATHABASKA GLACIER, COLUMBIA ICEFIELDS, ALTA.

A, the glacier; B, rock materials deposited along the edges of the glacier; C, the front of the glacier, where melting takes place; D, water from the glacier; E, a highway; F, layers of rocks, now near the top of the mountain, but formed many centuries before in the bottom of a sea.



to make huge water reservoirs, and exposing the land to weathering and erosion by cutting forests.

A Review Exercise

Plan a blackboard chart to summarize what you have learned about changes on the earth's surface. The title might be *Changes on the Earth's Surface,* and three column headings: Causes of Change, Wearing Down, and Building Up. Include such causes as: running water, waves, rain, glaciers, wind, gases in the air, plants, and animals.

CHANGING CLIMATES. Winters and summers come and go, and bring with them familiar kinds of work and play. Years pass. Yet weather records show that the temperature and the amount of rainfall have not changed much since the first explorers came to Canada.

When we think in terms of thousands of years, we know that the climate has changed greatly in many parts of the earth. Our western prairies, now covered annually by golden wheat, were once covered by an enormous glacier. For thousands of years no plants grew there. In other areas where today we mine coal, formed from the remains of jungle-like tropical forests, the winters are now so cold that such plants could not exist. These examples show that climates on the earth have changed since its formation. However, the changes are so gradual that the records of man cannot show them.

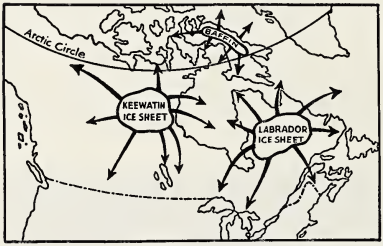


FIG. 13-6. THREE ICE SHEETS THAT ONCE COVERED MUCH OF CANADA.

CHANGING LIFE ON THE EARTH. Scientists believe that the first living plants and animals were very different from those we know today. They were too small to be seen with the eye, and they lived only in water. Some of the first animals were probably similar to sponges and starfish, snails and clams, as we know them today. Later, there were animals with backbones: fish; huge dinosaurs, resembling in some ways our snakes and lizards; and still later, birds and mammals.

Plants, too, have changed through the centuries. Many kinds that inhabited the earth when it was young no longer exist; some of these are still with us. Plant remains found in rocks tell us much about the ways in which plants have changed through the ages. By studying these remains, we conclude that large, tropical, fern-like trees once formed dense forests, even in Canada, and that, with the passing of long periods of time, these became today's coal beds. See fig. 13-7.

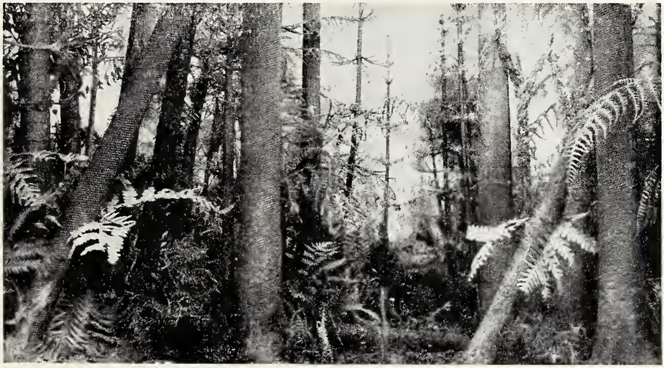


FIG. 13-7. A FOREST OF THE COAL AGE.

Scientists who study the earth and its rocks (geologists) have concluded that coal was formed from the remains of forests of trees like those shown above.

New Rocks from Old

"Rocks! What uninteresting things—dry, lifeless!" True, they appear the same year after year, drab, motionless, seldom attracting our attention. On them we live, move about, and build our homes. From them we derive our daily bread, our minerals, and our fuels. Without them there could be neither soil, nor plants, nor animals. Much human progress may be traced back to man's control of rocks and their minerals.

PUPIL INVESTIGATIONS. **Learn about the rocks of your community.**

1. Visit and study some of these: a quarry, a stone fence, a rocky cliff or a mountainside, a rock-cut along a railway or a highway, a gorge made by a fast-flowing stream, a gravel bank, a basement excavation, a creek bed. Try to find rocks (including clay) that appear to be in layers, and others that are not. Notice the colours and the fineness of grain of each kind of rock found.
With a hammer and a cold chisel, chip off pieces of several kinds of rock. (Protect your eyes when chipping rock.) Take the samples to your classroom for later study. Label each by name and origin.

2. Collect stones from the edge of a stream. Try to find out what makes them rounded and smooth. Break a brick into pieces about the size of a robin's egg, and place about a dozen of these pieces in a pint jar with water. Cover the jar tightly and shake it vigorously many times, examining the pieces occasionally. What changes in their shapes and surfaces took place? Repeat the experiment, using similar-sized pieces of stone. Do you think the stones in a gravel pit were once acted upon by moving water? Why?

THE FORMATION OF ROCK LAYERS. Nature, like people, never seems to be satisfied with what she builds. She is always creating something new out of the old. All through time she has been making new rocks out of old ones.

From Land to Sea Bottom. Some of our rocks are arranged in layers. Perhaps you wondered about these layers when you discovered them. We shall now find out why they occur.

We have seen how a heavy rainfall washes soil from a hillside, a park, or a country road, making a muddy pool. After the rain stops, the muddy water becomes clear and then dries up. A hard, dry layer of various-sized materials is left. Other rainstorms may add similar deposits on top of this. When we dig a hole where these layers have settled, we see their edges as laid down after the different storms.

Even the hardest rocks are gradually worn away or broken into fine pieces by the action of rain, running water, winter frost, summer heat, scouring by glaciers, or even the air itself. Many of these tiny rock particles are carried by streams until the water enters a lake or ocean and is slowed down enough to let them settle to the bottom as layers of gravel, sand, and mud. These layers of sediment at the bottom of the ocean become piled one upon another as the river brings down new loads of sediment after each flood. Naturally, as thousands of years pass, many layers are built up. See fig. 13-8.

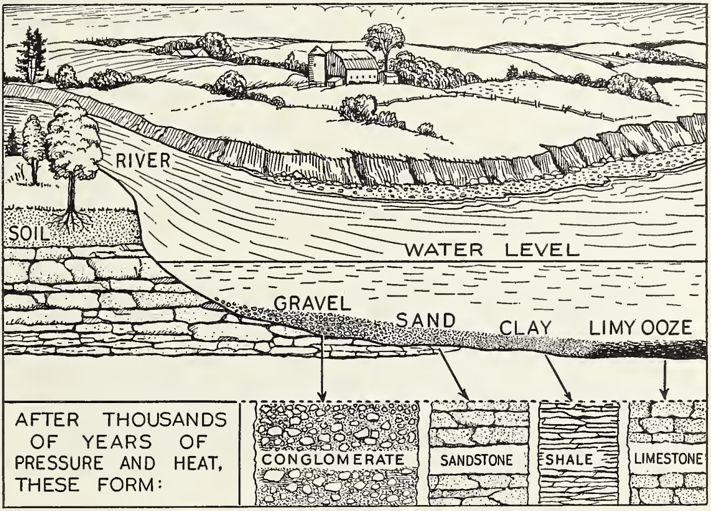


Fig. 13-8. From the Sediment of a River to New Layers of Stratified Rock.

EXPERIMENT 13-1. Do rock particles of different sizes and weights settle in water at the same time?

Nearly fill a quart jar with water. Mix a cupful of small pebbles, sand, and clay, and add these to the water. Cover the jar and shake the mixture of particles and water thoroughly. Watch the particles settle. Which settle first? Next? Last? Compare what you have seen here with the formation of the layer of sediment left by the muddy pool.

When the moving water of a river enters a large body of water, it is gradually slowed down. As it slows down, it loses its ability to carry along the particles of rock and clay which it has been carrying. The heaviest particles are dropped first, then the grains of sand, and finally the very fine particles. Therefore, the parts of the layers nearest the mouth of the inflowing river will be made up of the coarsest particles, gravel and coarse sand, while the parts farther out in the body of water will contain the finer material, fine sand and mud. The layers will be thickest near the mouth of the stream, where the water slowed down more abruptly. Study fig. 13-7.

From Sediment to Rock. Man makes several kinds of artificial rock. When a plasterer mixes sand, lime, and water, then leaves the mixture to dry and harden, he makes plaster, an artificial rock. Concrete is another man-made rock formed by mixing sand or gravel with cement and water, then leaving the mixture to harden.

Nature makes rock in a somewhat similar manner. For thousands of years rivers have deposited in the seas layers of gravel, sand, and mud, just as one snowstorm after another builds up layer on layer of snow. You see this layered arrangement when you dig a tunnel into an old snowbank. The lower layers are much firmer than the top ones: they have been pressed by the weight of the snow above. Similarly, the particles in the lower layers of sediment in the ocean are pressed firmly by the weight of the overlying material. At the same time, minerals such as lime and iron, in the sediment or from the water above, bind the particles together in much the same way as cement unites sand and gravel particles when we make concrete. In this manner each layer of sediment becomes a layer of rock.

Such layers of rock are called *strata* (plural), and rock formed in this way is called *stratified rock*. Because the rock is formed from sediment, it is also called *sedimentary rock*.

From Ocean Floor to Mountain Top. How did the layers of stratified rock that we see today get so far above sea level? Geologists (men trained to study rocks and other earth forms) have learned that a large part of Canada was once beneath the sea. The land rose, some of it high enough to become the peaks of the Rocky Mountains (fig. 13-5, F), and the water ran off to the ocean basins. Since that time, many changes have come about. Rivers have worn huge valleys through the rocks, leaving cliffs which show the strata that were formerly beneath the sea. We find examples of these at the Niagara Gorge, around Hamilton, and elsewhere.

KINDS OF SEDIMENTARY ROCK. Conglomerate. A mixture of stones, gravel, sand and finer particles, when cemented together and changed to rock, becomes conglomerate—sometimes called "pudding stone", because of the resemblance of its pebbles to raisins and currants in a pudding. Conglomerate looks somewhat like concrete (fig. 13-9, A).

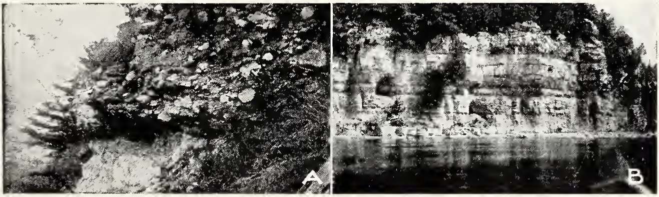


FIG. 13-9. TWO KINDS OF SEDIMENTARY ROCK.
A, conglomerate; B, limestone.

Sandstone. When the particles or layers of sand, whether coarse, medium, or fine, become cemented together, the rock formed is called sandstone. This rock feels rough and gritty, like sandpaper. Layers of it may be either soft and crumbly or very hard. Sandstone is used commonly today for buildings and grindstones.

Shale. Thin layers of mud, made up of fine particles called clay, harden to form shale (fig. 13-10). Although shale looks

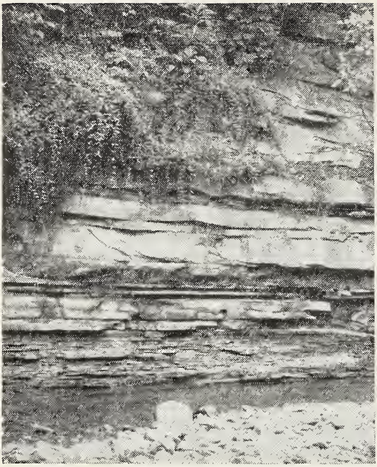


Fig. 13-10. Sandstone and Shale.
Sandstone: the thick, massive layers at the top.
Shale: the thin layers at the bottom.

like slate, it is soft enough to be broken in the fingers. Hence, it is useless for building. When wet, shale smells like mud, and gradually softens to form clay.

Shale and clay are the chief raw materials used for centuries in the making of bricks. Ground shale or clay is first mixed with enough water to make a putty-like mass. This is moulded to the shape of a brick, then baked or burned in a kiln until it is hard. Some shale is used in making Portland cement.

PUPIL INVESTIGATIONS. Try to find, then examine, specimens of conglomerate, sandstone, and shale.

Of what is the conglomerate composed? Feel the particles of sand in the sandstone. Try to dissolve some of the cement from between these particles by adding vinegar to the sandstone. What happens? Which of the three rocks breaks most easily? Which will scratch glass? What happens to shale ("stone mud") when it is exposed to the weather? Breathe on the shale and then compare its smell with that of moist clay or mud. Study the uses of clay as shown in fig. 14-3.

Limestone. Layers of limestone vary widely in thickness, and may be from white to grey or black in colour. Frequently they are separated by thinner, softer, and more irregular layers of shale. Because of its hardness, limestone is commonly used for monuments and bridges, and as building stone. It is also useful for the making of paper, rock wool insulation, lime, and cement, and in the smelting of ores. See fig. 13-9, B.

EXPERIMENT 13-2. How to test for limestone.

(a) Place a drop of vinegar or of hydrochloric acid on a piece of rock believed to be limestone. If bubbles form, the rock is either limestone or marble.

(b) Repeat this experiment, using the edge of a broken clam shell. Is there limestone in a clam shell? In a snail shell? In chalk? In bones?

(c) Place a few drops of well water on a piece of clean glass. What is left when the water evaporates? Test this to see if it is limestone. Test some of the grey deposit from a teakettle to see if it is limestone.

(d) All pupils collect samples of rocks from various sources. Test them to discover which ones are limestone.

Now we should be ready to understand how limestone is formed. River water, and therefore sea water, usually contains dissolved limestone. Animals such as clams, snails, and corals use this limestone to make the shells and other parts of their bodies. When they die, their limy parts collect on the bed of the ocean, along with the bones of other sea animals. As these shells and bones decompose, they form a layer of limy ooze. Pressed and cemented together for centuries, these layers become limestone rock or a softer kind of limestone, called chalk.

Gypsum. We know gypsum best by its products. It has been used as a plaster and as a building material since early Egyptian times. Alone, or mixed with sand or lime, it becomes wall plaster or stucco, or is manufactured into wallboard and lath and sold for building purposes. Made into plaster of paris and similar products, it is used by sculptors, surgeons, and dentists in making casts.

Gypsum wallboard and tiling have become popular with builders because they are durable, resist fire and water well, and provide good insulation against heat, cold, and sound. Like lumber, these building materials may be sawn and nailed.

Most gypsum is mined from thick beds, much as coal is. Some of these are at or near the surface of the earth; others are far below the surface. These beds of gypsum were formed by evaporation of sea water in bays that were cut off from the ocean.

CHANGED ROCKS. Shale and limestone continue to be changed after the particles of which they are made up become cemented together as solid rock.

Slate. When most of the water in shale is driven out by intense heat and great pressure, slate is formed. As a result of this pressure, slate splits easily into thin sheets, but does not break as easily, or soften and wear away as readily, as shale. These characteristics make slate useful for roofing and flooring.

EXPERIMENT 13-3. What are some other characteristics of slate?

Try to split a piece of slate. Compare its hardness with that of shale. Mark one piece of slate with another. What colour is the mark? How does the odour of slate compare with that of shale when damp?

Marble. When limestone is exposed to continued heat and pressure, it becomes changed to marble. Its fine grain, attractive appearance, and the ease with which it can be cut and polished have made marble popular as an ornamental building stone.

EXPERIMENT 13-4. Find out more about marble.

Describe the colour and appearance of marble. Place a few drops of vinegar or of hydrochloric acid on a small piece of it. What other rock bubbled when these acids were added? How does marble differ in appearance from limestone?

STORIES IN THE ROCKS: FOSSILS. History tells us about many of the things that have happened on the earth during the past five thousand years. However, the story of the earth stretches back many millions of years before there were any men to leave records of the life of the times.

The stories of very ancient times have been recorded in the layers of rock that have been built upon each other through the ages. The first chapters date back almost to the beginning of the earth. New chapters are being added constantly. The writing consists chiefly of the preserved remains of plants and animals.

EXPERIMENT 13-5. **To show how fossils were made and preserved.**

In a soup plate, mix thoroughly one part of cement with five parts of sand. Into this, stir enough water to make a mixture thick enough that it would just pour. (Or use plaster of paris thoroughly stirred into water until the mixture would pour like cake batter.) Embed in this soft layer small shells, bones, and bits of plant material. On its surface, make some finger-prints, marks resembling tracks, or ripple-like marks. Permit the layer to harden.

Brush a very thin layer of grease or vaseline over the hardened mass. Now add another layer of concrete or of plaster of paris. When this is hard, remove it. Notice that the markings on the surface of the lower layer are unchanged. Break the lower layer to find the preserved shells and other objects.

Let us imagine that this whole process took thousands of years, and that a snail was covered. Ages afterwards, the layer of sediment containing it had been covered by other layers, changed to rock, and lifted above the sea level. Through this rock a river cut its way, exposing to our view the shell, now a fossil, in the stone at the side of the stream.

PUPIL INVESTIGATIONS. **Make a collection of fossils.**

Visit a place where there are layers of sedimentary rock. Examine the flat surfaces and the edges for fossils. With a hammer and a chisel carefully remove as many fossils as you can find. Try to name them by comparing them with pictures in this chapter and elsewhere.

The plant and animal remains found on and beneath the earth's surface tell us much about the nature of the life, the climate, and the waters of ancient times. The huge bones and eggs scattered over the Mongolian Desert prove that at one time there were ancient reptiles, called dinosaurs, and show us what they were like. In the upper layers of sedimentary rocks, the last to be formed, fossil shells resembling our snails and clams show that animals similar to those of today lived millions of years ago. Fossils of ferns (fig. 13-12), bark, cones, seeds, and even insects, found in and between seams of coal, are evidence that the life, and therefore the climate, was tropical in Canada when the forests which later became changed into coal were growing.

As we explore further and examine older rocks, it becomes plain that the plants and animals of early times were much simpler in form than most of those in existence today. The oldest rocks contain no fossils, showing that while the earth was still young, there were no living things on it.

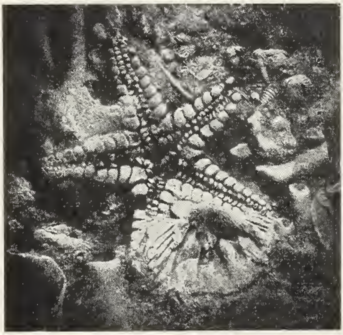


Fig. 13-11. A Fossil Starfish. This fossil starfish, found far from any bodies of salt water, has been well preserved in a layer of rock.

THE GEOLOGICAL STORY OF OUR OWN COMMUNITY. Every community has a history that belongs to it only. In terms of human inhabitants, the history may not go back more than a century or two; but in terms of mountains and hills, of rocks and fossils, of boulders and soil, and of streams and valleys, it goes back thousands of years.

The science which deals with the history of the earth and its life is known as *geology*. Men who make it their life's work to study the earth and to interpret the changes that have taken place on it are known as

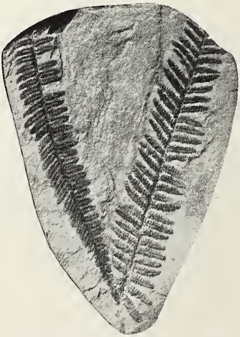
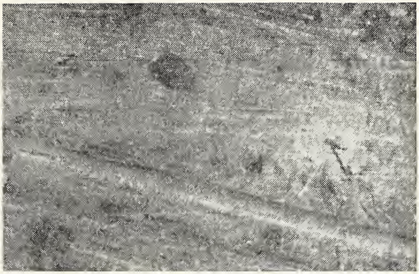


Fig. 13-12. Fossil Fern from a Nova Scotia Coal Field.

This photograph of the surface of a layer of rock next to a coal seam shows the impressions of two fern leaves that grew millions of years ago.

geologists. They learn a great deal from the edges of layers of rock exposed in the sides of cliffs or gorges. They explore, too, mountains and valleys, caves and mines, and help us to find nature's hidden treasures in the form of oil and natural gas, coal and iron, gold and silver.



Courtesy of the Royal Museum of Geology and Mineralogy, Toronto

FIG. 13-13. A SLAB OF SANDSTONE, SMOOTHED, SCRATCHED, AND GROOVED BY A GLACIER MANY THOUSANDS OF YEARS AGO.

Geologists have read many ancient stories written by Nature, and have interpreted these for us on geological maps. We can discover part of that history by our own observations and by using the information we have gained in this chapter.

PUPIL INVESTIGATIONS. Study the geological story of your community.

1. Find out whether the rocks in your region are stratified.

2. Your neighbourhood may show evidences that a glacier once passed over it. Look for these signs: pebbles having one side flat, and scratched or grooved, indicating that they may have been frozen firmly into the base of a glacier and ground against underlying rocks as the ice moved along; large surfaces of exposed rock showing grooves in one direction, probably gouged out by a glacier (fig. 13-13); large boulders on the top of the soil where they must have been left by a glacier (fig. 13-14).

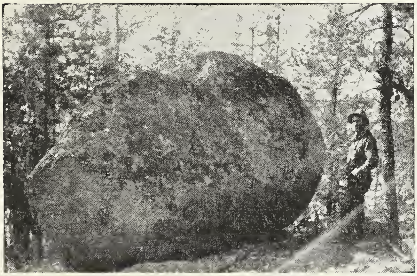


FIG. 13-14. GLACIERS OFTEN CARRY LARGE BOULDERS LIKE THIS GREAT DISTANCES.

The Earth's First Rocks: Igneous Rocks

Occasionally volcanoes break open and send forth flames and smoke, dust and melted rock (lava). The lava then hardens into a layer of rock somewhat as the melted impurities in a coal fire harden into clinkers, or molten glass becomes hard when it cools. The rock that is deep in the earth is always so hot that it will melt when the pressure above it is reduced enough. Any large break in the earth's surface lessens the pressure and causes this rock to soften and move upward. Some of it may reach the surface, flow over it, and harden on it as lava. Some hardens at considerable depth from the surface. Rocks formed in this way are called *igneous* rocks (from *ignus,* meaning fire). Study fig. 13-1 again.

All igneous rocks were at one time hot and molten. When they cooled slowly, as they do within the earth, the minerals in them formed crystals. Because of the crystals of minerals in granite, we know that it cooled slowly beneath the surface of the earth. When lava flows out from a volcano over the earth's surface, it cools quickly and forms fine-grained rocks which do not show crystals. Igneous rocks never occur in layers or strata because they are formed by the hardening of molten rock rather than from layers of sediment.

GRANITE. Much of the exposed igneous rock and many large boulders are composed of the rock called granite. This igneous rock always appears speckled because the crystals of which it is composed are large and of different colours. Granite is formed by the very slow cooling of molten rock deep in the earth's crust. When we find granite at the surface, it is likely that other rock has been weathered from above it, as has happened on the Laurentian Plateau.

Tombstones are often cut from granite. Its extreme hardness causes it to resist weathering, and its rich and varied colouring, which ranges from white to black, and from pink to red, gives it beauty. To make tombstones, slabs of granite are cut from a quarry, sawn to the desired size and shape, ground smooth, and polished.

PUPIL INVESTIGATIONS. 1. Of what is granite composed?

Examine a piece of granite with a lens. The parts with different colours are different kinds of materials. Read here the description of each kind of material as you find it in granite.

(a) *Quartz.* The glassy particles, usually white, are called quartz. Will the sharp point of a knife scratch these? Will a piece of the quartz scratch glass? Because very hard kinds of quartz strike fire with steel, they were used to make flints. Quartz is melted with soda or potash to make glass. Coloured forms of it are known as jasper, amethyst, onyx, and opal. When granite is worn down, the quartz forms sand particles which may combine later as sandstone.

(b) *Feldspar.* You will find the feldspar in more or less cubical pieces with smooth, flat surfaces having a pearly rather than a glossy appearance. They are pink in red granite, and white or grey in grey granite. The fact that the sharp point of a knife scratches feldspar distinguishes it from quartz. When granite breaks up to form soil, the feldspar becomes clay.

(c) *Mica.* Find thin, glassy sheets of mica scattered through the granite. They may be black, brown, or clear. Will a knife scratch mica? Dig out a sheet or flake. In early times mica was used for windows; now it is used as artificial snow and for insulating electrical apparatus. The best mica for spark-plugs in aeroplane engines comes from Ontario, particularly north of Kingston.

2. What is sand?

With a lens examine some sand. Look for grains of quartz with their uneven surfaces; flat, shiny pieces of feldspar; thin sheets or flakes of mica. As the rocks, especially granite, were weathered, these particles became separated.

Quartz always has the same characteristics, whether it is in granite or in sand. It is always made up of the same chemicals in the same proportions. For these reasons we call quartz a *mineral.* Feldspar and mica are minerals, too, for the same reasons. Because granite consists of minerals, it is called a *rock.*

For Investigation and Report to Class

1. Famous volcanoes and earthquakes.

2. Life at the time of the dinosaurs.

3. How the rocks of your community were formed.

4. The geological history of (a) your community, (b) the prairies of Western Canada, (c) the Laurentian Plateau, (d) the Niagara Escarpment, (e) the Rocky Mountains.

Things To Do

1. Make a peep show of life a million years ago. Include ancient trees, dinosaurs, rocks, fossils, etc.

2. Play the game of "Twenty Questions". Pupils should take turns acting as leader, beginning in each case by telling whether the thing in mind is animal, vegetable, or mineral. Include only things which are dealt with in this chapter.

3. Visit some of the following places or people to find out all you can about rocks, minerals, and metals: a quarry, a house being built, a foundry, a mine, a gravel pit, a plumber, a metal worker. Each individual or group should report in class the discoveries made.

4. Collect water-worn pebbles, pieces of gravel, crushed stone from roads, pieces of rock chipped from building stones, etc. Find the name of each kind of rock or mineral. Mount, label, and describe each briefly.

5. Make a model of the layers of rock seen along a gorge or cliff.

6. Examine the precious stones found in rings or other ornaments. Name and describe each.

Some Tests

1. Classify the following as sedimentary rocks, igneous rocks, metamorphic rocks, or minerals: granite, slate, shale, gold, nickel, sandstone, limestone, mica, quartz.

2. Account for the differences in the shapes and in the surfaces of stones found in a stream; stones found in a gravel pit; pieces of crushed stone.

3. Tell how water helps to form rocks.

4. Name five kinds of stratified rocks.

5. Tell how each of the following are formed: limestone, sandstone, conglomerate, gypsum, shale.

6. State as many uses as you can think of for each of: shale, limestone, gypsum.

7. Describe a test for limestone.

8. Tell how earthquakes are caused, and why they are so destructive.

9. What two conditions cause sedimentary rocks to become changed rocks?

10. Name the minerals that make up granite, and tell how you would recognize each.

A Matching Exercise

Match the following subjects and predicates to form true statements. Do it this way: 2 (a)—"The wearing away of rock is known as weathering."

Subject	Predicate
1. Glaciers	(a) is known as weathering
2. The wearing away of rock	(b) by carbon dioxide in water
3. Rocks may be dissolved	(c) are stratified rocks
4. Volcanic lavas	(d) make up granite
5. Limestone and conglomerate	(e) are called fossils
6. Mica, quartz, and feldspar	(f) are metamorphic rocks
7. Marble and slate	(g) may cover many square miles
8. Leaf imprints and dinosaurs	(h) settle from water before silt and clay
9. Gravel and sand	(i) make grooves in rocks

◆

Read

Compton's Pictured Encyclopedia: "The Earth" (several articles and many coloured illustrations), Vol. 4, pp. 172-195; "Fossils", Vol. 5, pp. 243-248; "How Old Mother Earth's Rocks Were Made", Vol. 12, pp. 167-170; and "Volcanoes—Fiery Vents in the Earth's Crust", Vol. 14, pp. 518-523.

16 mm. Sound Films

Geological Work of Ice (SG-11)

Wearing Away of the Land (SG-31)

Earth's Rocky Crust (SG-7)
Ontario Visual Education Branch.

Time and Terrain (a study in Canadian geology) (colour)
National Film Board, Ottawa.

14

ROCKS AND MINERALS IN MAN'S SERVICE

LOOK AROUND YOU. Notice the paint and plaster on the wall, the glass in the window, the concrete in the sidewalk, the steel in the fence. Think of the family automobile, telephone, and radio. All of these come from the rocks of the earth, from minerals contained in the rocks, or from soil made from the rocks. The steel was made from iron ore, the glass from sand, the plaster from gypsum, and the concrete largely from limestone. Doubtless, the paint contains some lead, or some materials from soybeans grown in the soil. Minerals supply the raw materials for the making of most of the equipment we use in daily life. It is almost impossible to overestimate the importance of minerals in our lives.

Minerals are particularly important to modern man because of his increased use of machinery. The automobile, tractor, and diesel engine now do the work done formerly by oxen, horses, and man. We use machines to clean our homes, to keep our food cool, to wash our clothing and dishes, and to mow our lawns. Minerals supply most of the raw materials for the manufacture of all these machines. Coal, natural gas, and fuel oil, which supply a large part of the power used to operate machinery, are minerals.

Rocks, Minerals, and Metals

ROCKS. Granite is called a rock because it consists of minerals. The three minerals in it are quartz, feldspar, and mica. Limestone, shale, slate, gypsum, and clay, found in natural deposits in the earth's crust, are also called rocks because they, too, consist of one or more minerals.

Although most rocks are hard and heavy, chalk, also a rock, is soft enough to be crumbled with the fingers, and pumice is light enough to float on water. Any natural deposit of hardened material that is a part of the earth's crust, and that consists of one or more minerals, is called a rock.

MINERALS. All the particles of quartz that we find in granite, and also in sand, have the same characteristics. All are made up of the same two elements, silicon and oxygen, and these are always present in the same proportions. For these reasons we call quartz a mineral.

Any mineral—feldspar, mica, gypsum, gold, asbestos, etc.—always has the same characteristics, and is made up of the same chemicals in the same proportions. Any substance that exists in nature and always has the same characteristics and the same chemical composition is called a mineral. Salt occurs in nature, always tastes the same, and always contains the same two elements: therefore, salt is a mineral. For the same reasons, water is a mineral.

The minerals quartz, feldspar, and mica occur in granite as crystals of a definite shape. Many other minerals occur in nature in the form of crystals.

EXPERIMENT 14-1. To understand how mineral crystals in rocks are formed.

In separate dishes of hot water dissolve as much as you can of sugar, common salt, alum, copper sulphate (bluestone, a poison), and potassium bichromate (used in blueprinting, also poisonous). Leave a cloth-covered wire or a suspended string in each solution. Watch crystals form on the wire or the string and grow larger from day to day. Compare the shapes of the crystals. Repeat the experiment, using a strong solution of mixed chemicals.

In a similar manner, minerals dissolved in water in the earth's crust may form crystals in crevices in rocks. Ages ago, when granite cooled from a hot, molten state, crystals of quartz, feldspar, and mica were formed and joined together.

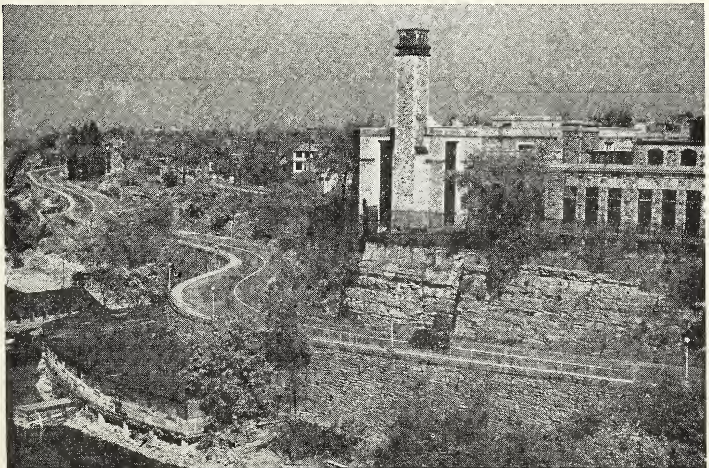
Minerals are divided into three groups: metals, non-metals, and mineral fuels. Gold, silver, copper, iron, tin, radium, nickel, aluminum, and lead are metals. They all have a dull lustre, called a metallic lustre; they are easily hammered or worked into various shapes; and they conduct heat and electricity well. Minerals classified as non-metals include clay, sand, limestone, marble, slate, asbestos, quartz, mica, asphalt, sulphur, and such fertilizers as nitrate and phosphate. These do not have any of the three characteristics of metals. Minerals used as fuels are coal, natural gas, and petroleum.

Rocks as Construction Materials

Men of ancient and mediaeval times depended largely upon blocks of stone for building purposes. With these they constructed the massive pyramids of Egypt, the Great Wall of

FIG. 14-1. THE ROYAL MINT AND LADY GREY DRIVE BESIDE THE OTTAWA RIVER IN OTTAWA.

Rock was used in many ways in the constructions seen here; natural rock as a foundation for the Royal Mint; ornamental stone in many parts of the building; stone in the retaining wall; and crushed stone in the roadbed. Perhaps you can find other uses for rock in this scene.



China, and the beautiful cathedrals of Europe. Today we use a wide variety of rocks and minerals to construct and ornament bridges and highways, public buildings and homes, memorials and statues. Science has taught us many new uses for the rocks and minerals of the earth's crust.

Pupil Investigations

1. *How rocks and their products were used in constructing your house.* One pupil might investigate and report for each of the following parts: foundation, outside walls, roof, window sills, floors, insulating materials, window glass, inside plaster, hardware, heating system, tiling, drains, and plumbing. Include the use of stone, brick, slate, concrete, lime and mortar, rock wool, asbestos, iron, copper, and nickel.
2. *How rocks and minerals are used in your community.* Consider public buildings, bridges, pavements, memorials, machinery, and all kinds of transportation and communication systems. Name the kinds of stone and other mineral materials used in their construction.
3. *How the pyramids of Egypt were built.* Find out about their size, the kinds of stone in them, the weights of the blocks used, the methods of hauling and placing the blocks, and the time required to build one.
4. *How building materials are made.* Find out how these are made: Portland cement, concrete blocks, bricks, tiles, and gypsum wallboards.

BUILDING STONES. Granite, sandstone, limestone, and slate are the rocks most commonly employed for building purposes. They have the following favourable characteristics: they can be cut or hewn into desired shapes with comparative ease; they resist weathering; they are strong enough to support great weights; they are so hard that they do not absorb much water and consequently are not liable to be damaged by frost; they are attractive in appearance.

Granite, the hardest, strongest, and most beautifully coloured of the four, is used chiefly in public buildings, bridges, and monuments. The firmest sandstones are second in hardness and strength. Limestone, being softer, weathers more quickly than granite and the best sandstones. Because slate splits in thin sheets, it is used for roofs, floors, and steps.

OTHER CONSTRUCTION MATERIALS. Asbestos has many uses in building. Because it is fireproof, durable, and a good insulator against heat and cold, it is made into shingles, building paper, pipe covers, insulating cement, and fire-proof paint. For the same reasons, gypsum is used for wall plaster and wallboard. Crushed limestone is important in highway construction and in the making of cement and lime. Clay and shale become bricks, and sand and gravel make up the largest part of concrete.

Minerals in Daily Life

MINERALS SATISFY MANY EVERYDAY NEEDS. "Animal, Vegetable, or Mineral" includes everything man uses in daily living. Of these, the gifts of the mineral kingdom are almost unlimited. From minerals we make kitchen utensils, tools and machines, paints and protective coverings. We use minerals in agriculture, in manufacturing, in construction, in communication and transportation, also for our health and for many other purposes.

A Blackboard Chart. Plan a chart somewhat like the one below. The paragraph above will suggest other uses you might list in the column at the left. After each of these, list as many minerals as you can, then tell how each is used in daily living. Some minerals may be listed more than once.

Some Uses of Minerals

Kind of Use	Minerals	How Used
Utensils	Tin	plating cups, containers, or canned goods, etc.
	Aluminum	cooking utensils, pails, and cups
	....	....
Tools and Machines	Iron	....
	....	....

ASBESTOS, THE CLOTH THAT WILL NOT BURN. Cloth made from fibres of mineral! Yes, from asbestos, called "cotton stone" by the early French settlers in Quebec! When mined, asbestos is greenish in colour and has a lustre like that of pearls. Usually it is found in layers between other kinds of rock. When the rock has been crushed, the soft, silky, white fibres may be separated from the waste material (fig. 14-2). When spun and woven like fibres from plants or animals, these fibres make asbestos cloth.

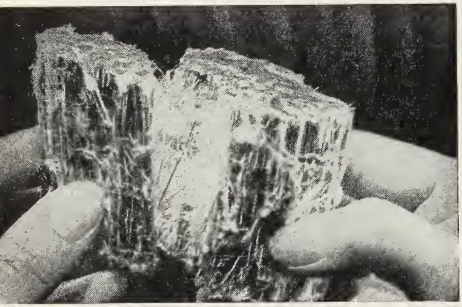
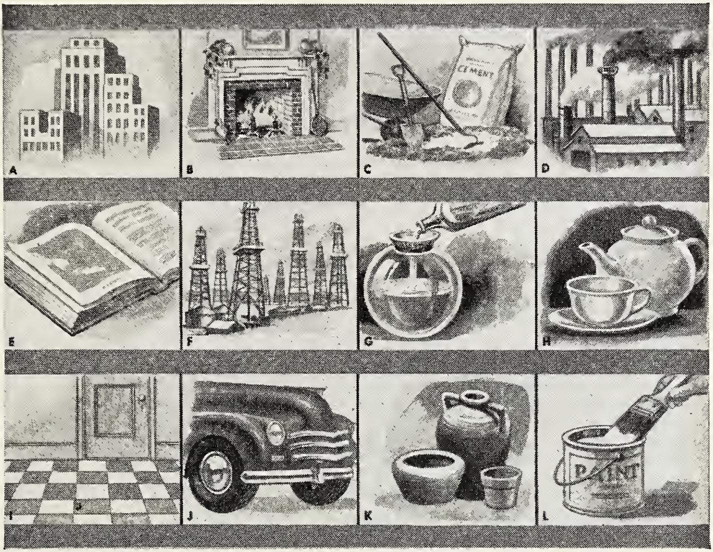


Fig. 14-2. Asbestos.
Notice that the fibres extend crosswise in a layer of mineral asbestos. The thicker the vein of asbestos, the longer and more valuable is its fibre.

Asbestos has many uses. Because it is fireproof and a poor conductor of heat, clothing made from it is suitable for fire-fighters and for those who tend very hot furnaces. For the same reason, asbestos is used in stage curtains, on furnaces and furnace pipes, also for shingles, table mats, and brake lining for automobiles and elevators. Other characteristics which make asbestos very valuable are: it is not affected by acids, heat, cold, or dampness; it does not conduct electricity.

CLAY AND ITS USES. Clay is one of man's oldest servants. Prehistoric man discovered that he could mould it to any desired shape, then harden it by baking. Soon he found many ways of using it—to make pottery vessels, to plaster the walls of his huts, and to make bricks. Centuries of inventions have failed to make much improvement upon the ancient ways of handling clay, but have added some new uses. Today we use clay in making cement, drainpipes, fine paper, and rubber tires. It becomes the lining of modern industrial ovens and furnaces. As of old, we still use it to make bricks, tile, and chinaware. See fig. 14-3.



(*Compton's Pictured Encyclopedia*)

FIG. 14-3. COMMON CLAY HAS MANY IMPORTANT USES.

Clay bricks have been used by man for many centuries. Bricks made by the Babylonians 6,000 years ago are still in existence. Egypt used clay from the Nile for her bricks. In nearly every community where suitable clay is available, brick making continues to provide employment and useful products for man. See fig. 14-4.

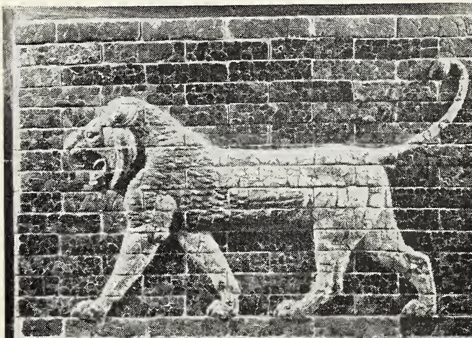


FIG. 14-4. BRICKS TWENTY-FIVE CENTURIES OLD.

A winged lion of glazed earthenware bricks, made in Babylon about 600 B.C.

(*Royal Ontario Museum of Archaeology*)

Clay for bricks is dug by machines, crushed, sifted, and mixed with water. The mixture is then kneaded until it is thick enough to retain its shape. As it is forced from a pug-mill in long columns of the desired shape, the pressed clay is cut by wires into blocks, each the size of a brick. After being partially dried by warm air, the bricks are heated in a furnace or kiln to a temperature of about 2,000°F. for two or three days.

PORTLAND CEMENT. Because of its use in concrete sidewalks, highways, foundations, building blocks, and floors, Portland cement is a very important mineral product. It is made chiefly from limestone and clay. These are ground together and heated so intensely that they form small lumps of clinker. When cool, the clinker is mixed with a small amount of gypsum, then ground to a fine powder. Cement is shipped in paper sacks to keep it perfectly dry until it is required to make concrete.

FROM SAND TO GLASS AND CARBORUNDUM. Glass. There is a legend that thousands of years ago a group of Phoenician sailors stopped on a beach of clean, white sand to cook their evening meal. In the absence of stoves, they had to unload some blocks of nitre, a form of soda, to hold up their cooking pot. Dried seaweed was handy fuel. Behold, in the morning a shapeless lump of glass in the ashes, made from melted sand, soda, and the potash of seaweed!

Fig. 14-5. Filling a Cart with Raw Materials for the Making of Glass.

These ingredients have been carefully measured and mixed and are ready for melting.

If we were to visit a glass factory today, we would be shown great piles of snow-white sand, limestone, and soda, and a supply of about thirty other chemicals. In the mixing room we would see workmen carefully measuring out exact amounts of each material, putting them into whirling electric mixers, then into huge pots with fire-clay brick walls that withstand terrific heat. See fig. 14-5.

Elsewhere, we would see molten glass being blown into beautiful goblets, or pressed into cups, saucers, plates, and bowls.

In another kind of glass factory, we would see molten glass being poured between huge rollers to be pressed into a wide, flat plate of glossy, hot glass, 60 feet long. This would be passed through a tempering oven, cooling as it moved along, then from one huge rotating grinder to another until it became a piece of perfect plate glass, ready to be used as a window or a mirror.

Carborundum. Modern science and industry has many uses for extremely hard cutting and grinding materials, called abrasives. Of these, emery, corundum, garnet, and sandstone are found in nature. About half a century ago, an electric current, passed through a mixture of clay and coke, produced the first man-made abrasive crystals. These were so hard that they scratched a real diamond. Now huge electric furnaces, kept hot enough to melt rock and steel, change a mixture of coke, sand, sawdust, and salt to tiny grains of silicon carbide. Bound together by a fine cement, these grains become the hard grinding wheels that drill our teeth and sharpen tools for the home, the shop, and the farm. Carborundum, the first man-made abrasive, is mostly mineral, and is truly one of modern man's most useful servants.

Ores and Metals

Gold, silver, and copper are found in nature in a pure state. Other metals, such as iron, lead, nickel, and aluminum, are obtained from *ores*. These are rocks or minerals from which we may obtain metals in sufficient quantities that it pays to mine and smelt them.

HOW ORES WERE FORMED. Ores usually occur in *veins* filling crevices in rocks. Scientists think ores were formed in the following manner. After the rocks, such as granite, had been formed (as described in chapter 13), crevices frequently developed in them. Minerals from the deeper and hotter parts of the earth's crust either dissolved in hot water or heated until they were molten, pushed up into these crevices. As the solutions or the molten minerals cooled, the minerals formed crystals. These were deposited in the crevices and formed the veins of ore.

Scientists believe iron ores were formed somewhat differently. The water of ancient seas and lakes often contained some iron-bearing substances. These materials settled when the water evaporated and, as they hardened, formed reddish, yellowish, or dark grey iron ore. Over such ores, beds of mud collected and hardened to form shale. If this rock has not been removed by weathering through the ages, miners must cut through it to obtain the iron ore.

METALS USED BY EARLY MAN. It was perhaps 15,000 years ago that some fortunate hunter found a piece of copper and made it into a crude weapon. He learned that copper was easier to work with than stone. The ancient Europeans found that bronze, a mixture of copper and tin, made harder and stronger tools, and for a long time bronze was the chief metal used. We call that period the Bronze Age.

Then came the Iron Age. We have a story that in the far-distant past there lived a very strong man, Tubal Cain, a grandson of Methuselah. He knew well how to make and tend a tribal fire, and how to guard a tribal village against the attacks of prowling beasts. As he sat before a particularly large fire, he noticed the stones beneath melting and sending out a stream of molten rock which soon hardened. He had discovered iron. This he used to fashion spear heads and to make sharp weapons.

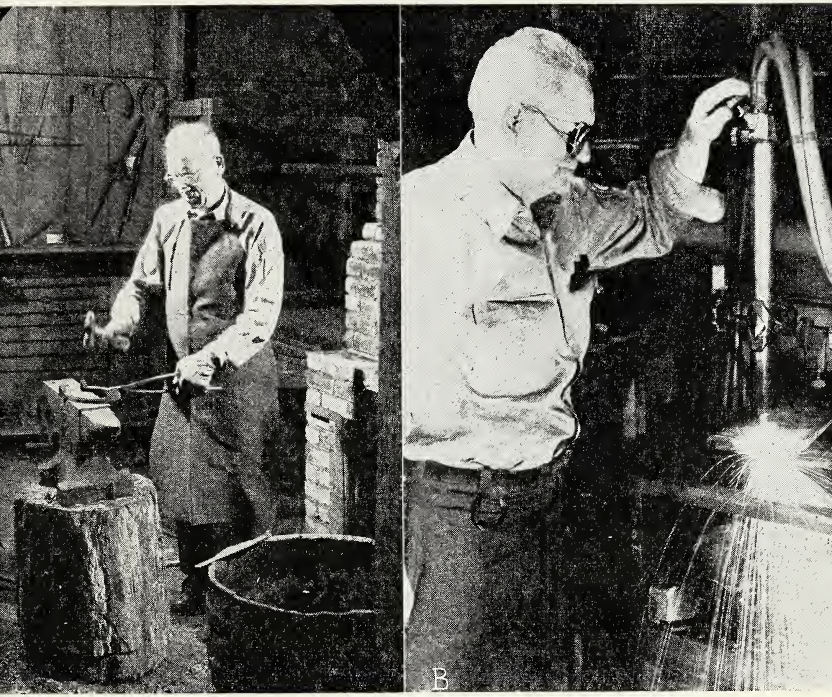


Fig. 14-6. Changes in Half a Century.
A, a blacksmith using a forge, anvil, and hammer to shape a horseshoe; B, a modern ironworker using an oxy-acetylene torch.

FROM IRON ORE TO STAINLESS STEEL. We will understand better how we get iron from iron ore if we recall how iron rust is formed. This red coating is produced when iron combines with oxygen in moist air. Likewise, iron ore consists of iron combined with oxygen. To change iron ore to iron, we must remove the oxygen from it. This is done by heating the ore to a very high temperature in the presence of coke. The coke takes the oxygen away from the iron ore, and iron is left. The process of removing oxygen from iron is called *smelting*.

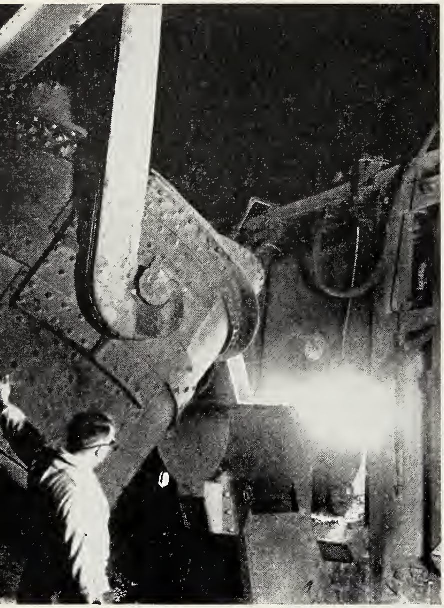


FIG. 14-7. POURING MOLTEN PIG IRON INTO AN OPEN HEARTH FURNACE.

The earliest records of smelting are found in Egyptian tombs. Probably the first iron smelters were dome-shaped furnaces into which was put a mixture of iron ore and charcoal. The charcoal was ignited and left to burn slowly. In later years the Spanish iron-workers learned that they could hasten the smelting process by using a bellows to force air into the mixture of iron ore and charcoal.

Today, a mixture of iron ore, coke, and limestone is poured into a huge blast furnace, and a forced draught of hot air is blown into the furnace. When this mixture has melted, the pure iron, in a molten state, settles to the lower part of the furnace, beneath the impurities which are called slag. The slag is drained off through openings in the sides of the furnace above the level of the molten iron, and the molten iron is drained off from the bottom of the furnace into huge ladles on railway cars. From these it is poured into moulds where it hardens as *ingots* of *pig iron*.

Steel is better than iron for many purposes, largely because it is less brittle. We make steel from pig iron by remelting it and causing it to combine with such other substances as carbon and manganese. To obtain stainless steel, which does not rust or stain, we add chromium, nickel, and manganese to molten iron. The molten steel is usually poured from furnaces into moulds. Later it is manufactured into useful tools and machines.

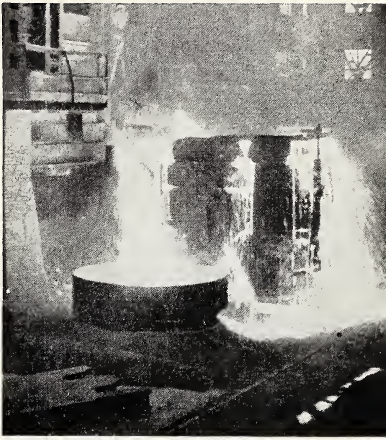


Fig. 14-8. Molten Steel Produces a Shower of Sparks as It Is Poured Off into Ladles or Moulds.

SILVER, FROM ORE TO SPOON. To the early Greeks, silver was the "noble metal". Idols were made of it, and temples were decorated with it.

Silver was used in America before Columbus arrived. English seamen in the reign of Queen Elizabeth I scoured the seas for the silver carried on Spanish treasure ships from Spanish colonies in America. Silver has been, and is, the chief metal of the world's coins. It is used extensively in photography and in the making of cutlery and silverware.

When silver ore is removed from the mine, it consists of rock containing silver and other chemicals. Several processes are used to separate the silver from the ore. While hot, the metal is poured into moulds where it hardens as pure silver.

Sterling silver must contain 92½ per cent pure silver, an amount fixed by law. The other 7½ per cent is copper, used to give hardness and durability.

Silver plate is a less costly substitute for sterling silver. It is made by using an alloy, usually nickel silver, as a base, and placing a thin coating of pure silver on its surface, that is, plating it with silver. The process is known as electroplating.

A NEW USE FOR CLAY. "On the morning of February 23, 1886, a young man of 22 stood anxiously over a complicated mass of electric wires, crucibles, and heating apparatus in a woodshed in Oberlin, Ohio. For two hours Charles Martin Hall watched as the contents of one of the crucibles grew hotter and hotter. Finally, he turned off the powerful current and, shaking with excitement, poured out the molten mass. A number of little silver-coloured drops had separated, and they quickly hardened into shining buttons of metal.'"[1] Hall had discovered a cheap method of making aluminum.

Through the centuries clay was thought of as just clay—raw material for the making of brick and pottery, and a nuisance in rainy weather. Now a special form of clay, called bauxite, gives aluminum when refined by the chemical and electrical process discovered by Hall.

Aluminum is used in many ways. Because it is durable, heats quickly, and is easily cleaned, it has become popular in kitchen utensils. Because of its lightness and strength, new uses are constantly being found for it in the manufacture of automobiles, railway cars, steamships, aeroplanes, and electrical equipment.

HOW MAN GETS METALS FROM ORES. Most metals are obtained from their ores by three main processes.

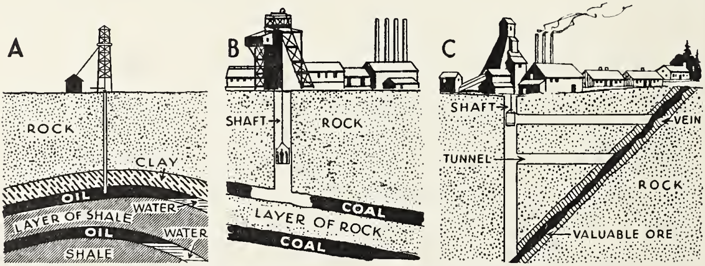


Fig. 14-9. How We Obtain Oil, Coal, and Mineral Ores.

A. From the oil derrick (rig) an iron pipe extends down through the hole drilled in the rock to the pocket of oil. B. Coal is carried in elevators from the underground coal seams up through the shaft to the pit head and processing buildings. C. Ore is transported from the vein along the tunnel and up through the shaft.

---

[1] From Compton's Pictured Encyclopedia.

Separating Minerals from Useless Rock Materials. When geologists have discovered a vein that seems valuable, a shaft is dug down to the proper depth, and tunnels are cut to and into the vein. The ore, sent up the shaft by the underground miners, is crushed and ground into a fine powder. Then the valuable mineral matter, *concentrate,* is separated from the useless rock materials.

Smelting Mineral Concentrates. A powdered mineral concentrate is chiefly mineral. It contains the metal combined chemically with other substances. The metal is usually separated from these by roasting the powdered mineral intensely, or by heating it with coke, or by both steps.

Refining Metals. A pure metal, such as the gold in gold bricks, can be produced only by a process of refining. The process used depends upon the metal to be refined. Electricity is used extensively in refining processes. See fig. 14-10.

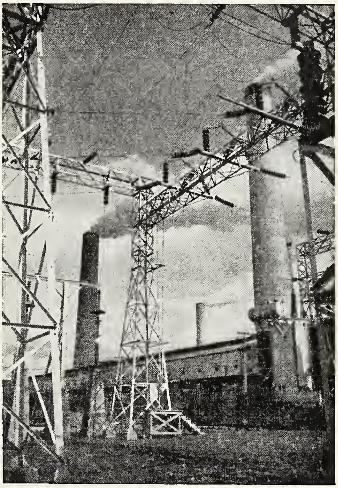


FIG. 14-10. A NICKEL REFINERY AT PORT COLBORNE.

Here is the meeting place of four of Canada's most important products: nickel from Sudbury district, electricity from Queenston, coal from Nova Scotia, and Canadian oil and lubricants.

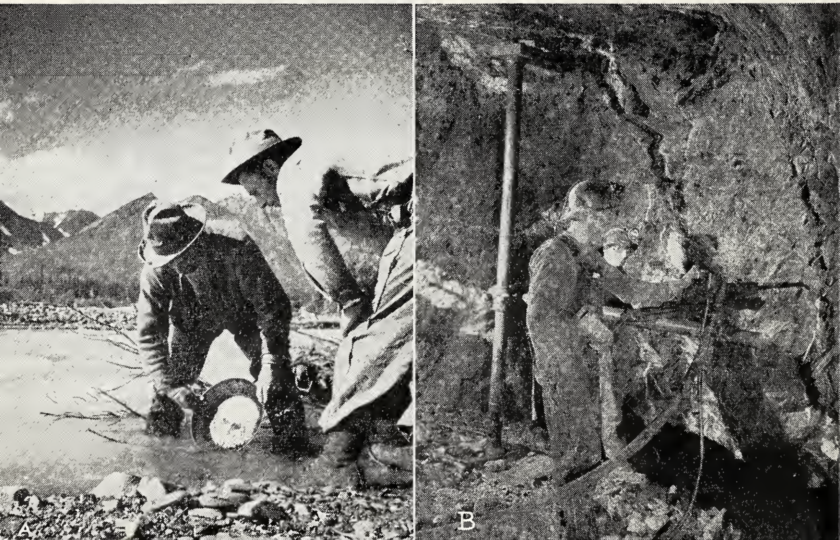
SOME OTHER METALS OF EVERYDAY USE. Several metals, in addition to iron, aluminum, and silver, serve us well in everyday living.

Copper. The fact that copper does not rust or corrode makes copper utensils and copper piping for household use increasingly popular. Because it is a good conductor of electricity and does not break easily, copper is the chief metal used for making electric wires. For centuries it has been combined with tin to make bronze, which is stronger than either metal alone. With zinc, copper produces brass, popular for its hardness, permanence, and attractive sheen when polished.

Nickel. Without nickel we would have neither stainless steel nor nickel-plated trimmings on automobiles, trains, and household furnishings. With chromium, it is essential for making hard steel for high-speed cutting tools, guns, armour-piercing projectiles, armour plate for ships, and gears for many kinds of machines.

Lead and Zinc. Lead is important in the manufacture of solder, type metal, plumbing pipes, and paint. Zinc is used to galvanize iron, preventing it from rusting. Combined with copper, zinc produces brass.

FIG. 14-11. TWO METHODS OF OBTAINING GOLD.
A, panning for gold in the Yukon within a mile of the Alaska Highway; B, drilling rock to obtain gold ore.



The Mining Industry Is Important to Us

Minerals have been important to man from the very earliest times. Each time he learned how to make another of the earth's metals work for him, man climbed a little higher on the ladder of civilization. After thousands of years of working with stone (the Stone Age), man discovered that copper and bronze served him better. Then, 1,000 years before the birth of Christ, he learned how to use iron, and so began the Iron Age. The Machine Age, in which we live today, shows man's increasing ability to adapt iron and other metals to his service.

Mines and mining have determined the history of nations. Egypt's knowledge of copper and its uses made her strong. During the time in which Spain controlled the silver and gold of Mexico and Peru, she reached the height of her power. England's resources of iron and coal gave her a leading place in the development of the modern Machine Age.

The mining of gold, nickel, and silver has been largely responsible for the development of Northern Ontario. The mining of coal gave Cape Breton Island its place of importance in the Maritime Provinces. Without its great natural resources of natural gas and petroleum, the Province of Alberta could not have developed as it has.

MINING PROVIDES THE MATERIALS FOR MANY INDUSTRIES. Minerals such as the ores of nickel, iron, and copper become raw materials for smelters and refineries. Industries that manufacture machinery, equipment, and utensils of iron, steel, copper, asbestos, and aluminum depend upon mines for the raw materials they use. Industries such as agriculture, forestry, and transportation are helped indirectly by the mines, which make possible the equipment and machinery they use. A shortage of iron ore may cause a steel company to stop work, an automobile manufacturer to cease production, and, as a result, a transport company to be without trucks.

MINING GIVES A LIVING TO MANY PEOPLE. The discovery of an important mineral leads to the employment of many people. Prospectors and mining engineers try to discover the exact location of the mineral deposits. Drilling companies set to work to obtain samples of the mineral to determine whether it will be profitable to mine it. Construction men dig the shafts, provide for water supplies, and install power and ventilation equipment. Other people earn a living by building roads and railways to the area.

When the actual mining begins, employment is given to officials, engineers, foremen, miners, and office workers. Homes are built. Stores are opened to supply the household needs. Schools, churches, hotels, and garages are erected. Soon there is a thriving town with all the usual opportunities for making a living.

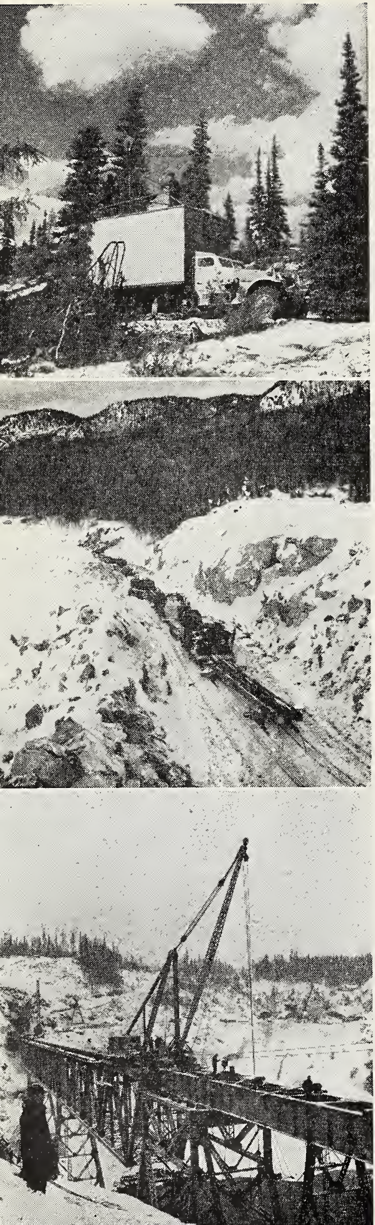


Fig. 14-12. The New Iron Mining Industry in Labrador and Eastern Quebec Gives Labour to People of Many Occupations.

Top, exploring for iron with a diamond drill; *middle*, conveying equipment and supplies from Seven Islands, P.Q., to Menihek Power Project at Burnt River, P.Q., travelling on the completed railway roadbed; *lower*, building a railway bridge for the Quebec North Shore and Labrador Railway, part of the biggest task in railway construction since conquering the Rocky Mountains.

A new mining town gives employment to people beyond its boundaries: to those who work in smelters and refineries; to those who build highways and railways; and to those engaged in the transportation industries, taking minerals or metals from the mines and bringing equipment and goods to the mine and to the townsfolk. Mining provides employment and an income for many people far and near.

MINING IS A SOURCE OF NATIONAL WEALTH. Mining means much to Canada. For the past few years enough minerals have been produced in our country to pay every Canadian $50 or more per year.

[1]Canada stands first in the world in the production of nickel, asbestos, platinum, and radium; and second in the production of gold and aluminum. For several years Canada has been among the first four nations in the production of silver, zinc, copper, and lead.

The vast Canadian Shield, which covers the north-eastern part of Canada and extends to the prairies, produces all of Canada's nickel, platinum, and cobalt; 85% of Canada's gold; and 86% of Canada's copper. The Cordilleran Region, including British Columbia, the Yukon, and part of Alberta, mines nearly all of Canada's lead, 96% of her oil, 70% of her zinc, and 60% of her silver. Most of Canada's gypsum comes from the Maritime Provinces and Ontario. Northern Alberta probably contains the largest natural resources of oil in the world.

Minerals Must Be Conserved

We live in a machine age. We use tractors, trucks, automobiles, and diesel engines to do the work that horses and man did a few decades ago. These machines use coal, fuel oil, and gasoline in greater quantities than mankind ever used them before. The machines themselves are made of iron and

---

[1] Data given herewith taken chiefly from "Geology and Economic Minerals of Canada", Third Edition.

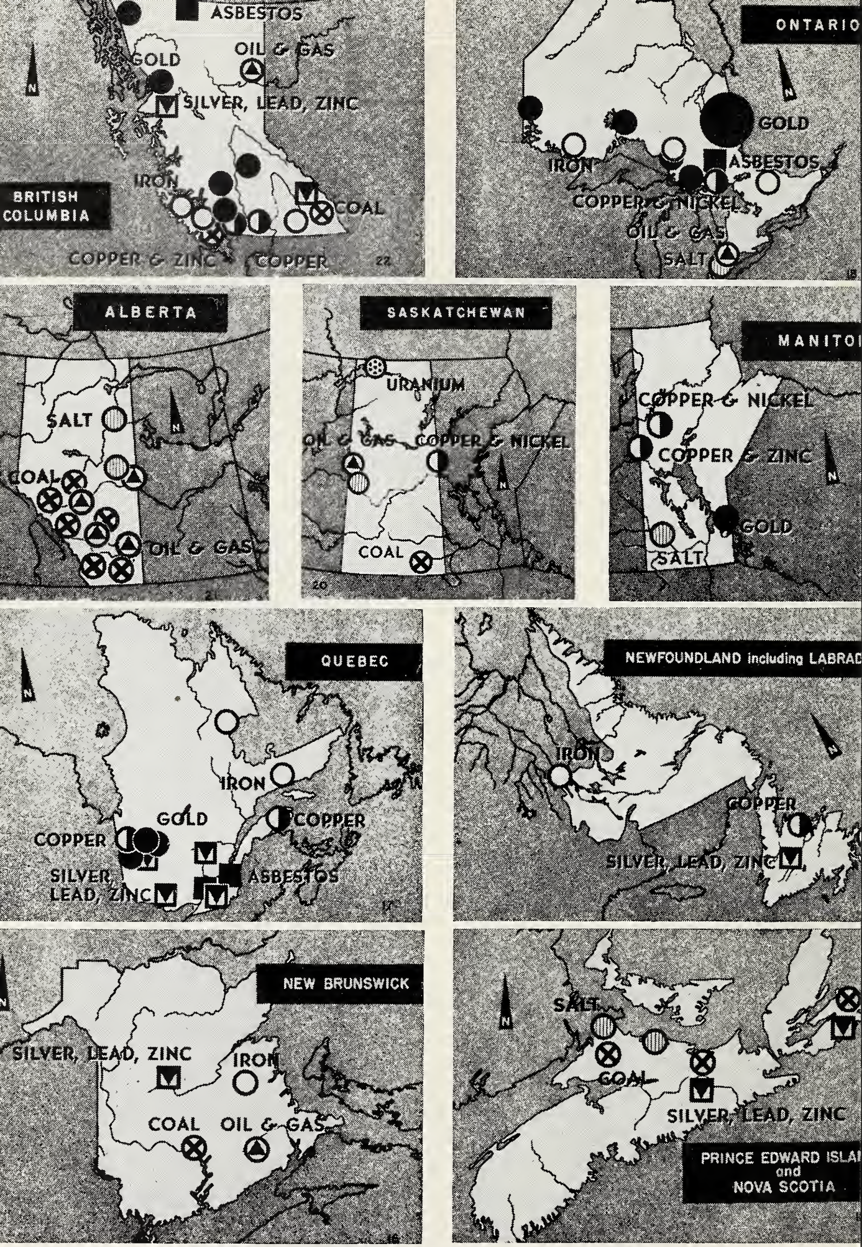


Fig. 14-13. The Mineral Areas of Canada.

steel, aluminum, copper, and other minerals. In fact, nearly three-quarters of everything we use comes from minerals.

Minerals and mineral fuels are destroyed with use. New supplies must be removed from the earth's crust to take their place. The supplies of coal, oil, iron, copper, and other minerals are limited. Once used, they can never be replaced.

Minerals May Be Conserved

Minerals	Methods of Conservation
Iron and Other Metals	Reduce waste in mining: conserve all ore, not only the richest; use the most efficient machinery. Save and re-use all scrap metal. Care well for tools, machinery, tractors, automobiles, etc.: keep them lubricated and protect them from weather and rusting. Use substitutes: plastics and glass.
Coal	Reduce waste in mining: use coal from small as well as large seams. Use coal more efficiently: reduce waste in smoke by tending furnaces more carefully. Prevent waste of heat: insulate buildings; avoid overheating them. Use water power in place of steam power.
Petroleum, Fuel Oil, and Gasoline	Reduce waste in production, distribution, and use. Operate heating plants, gasoline engines, etc. more efficiently. Develop substitutes.

The supplies of these in the earth's crust—the natural resources upon which we depend so much—are, therefore, becoming less and less.

Although we are constantly finding new deposits of coal, iron, and petroleum, some day Canadians will have found the last deposit of each. Some day there will be no more coal, no more petroleum, no more iron ore! How unfair we are to those who come after us if we carelessly hasten the coming of that day.

To conserve minerals means to use them wisely. It means to prevent their waste from the time we find them in the earth until they have served our purposes. The table on page 245 summarizes some steps that can be taken to conserve minerals.

Some Learning Activities

1. Find out how copper, nickel, and gold are separated from their ores.
2. Make a pictorial map of mining in Canada, showing such important features as: aluminum production at Arvida and Shawinigan Falls (P.Q.); copper mines at Sudbury and Noranda (Ont.), Flin Flon (Man.), and Copper Mountain (B.C.), and refineries at Copper Cliff and Montreal East; gold producing areas in Ontario, Quebec, and British Columbia; iron deposits at Steep Rock (Ont.) and in Quebec and Labrador; lead mines at Kimberley (B.C.) and in the Yukon, and the smelter at Trail (B.C.); nickel smelters at Copper Cliff and near Sudbury, and the nickel refinery at Port Colborne; silver mines in B.C., Ontario, and the Yukon; zinc refineries at Trail (B.C.) and at Flin Flon (Man.); asbestos sources in Eastern Quebec; uranium sources in Canada; and areas where silver, lead, and zinc are found together.
3. Make a class collection of specimens of iron, steel, copper, nickel, bronze (copper and tin, with or without lead and zinc), brass (zinc and copper), solder (lead and tin), and a silver coin (silver and copper). Label each specimen to show its name and common uses.
4. Consult the Canada Year Book to find the annual production of each kind of mineral in Canada.
5. On a map of Canada, mark (a) the chief deposits of each important mineral, (b) the position and name of each important city or town in or near which the main industry is mining.

6. Make a list of the main uses of iron, copper, aluminum, gypsum, silver, nickel, lead, petroleum, natural gas, and asbestos.

7. Collect specimens of as many different kinds of rocks, minerals, and ores as you can find. Label each. Obtain samples of other kinds from the Department of Mines and Resources, Ottawa.

8. Move a magnet through some sand to find out whether it contains any iron.

9. Investigate and report to class the story of some mine and the community around it from the time the ore was discovered until the mine was in full production.

10. On separate outline maps of Canada mark the oil fields, the coal areas, and the regions producing natural gas in quantity.

For Discussion

1. What are the differences between rocks and minerals? Between minerals and metals?

2. Agriculture and forestry depend upon the mining industry in Canada.

◆

Read

Compton's Pictured Encyclopedia: "The Work of Smiths of Many Ages and Countries", Vol. 9, pp. 177-179; "How Man Wins Treasure from the Earth's Depths", Vol. 9, pp. 267-275; "The Making and the Laying of Brick and Tile", Vol. 2, pp. 302-305; "Mining Coal for Heat, Power, and Chemicals", Vol. 3, pp. 361-371; "The Diamond — Sparkling Cousin of Coal", Vol. 4, pp. 78-81; "Iron and Steel", Vol. 7, pp. 235-249; "Pottery as an Industry and a Fine Art", Vol. 11, pp. 393-401; and "Petroleum", Vol. 11, pp. 169-181.

16 mm. Sound Films

Story of Coal (SS-45)
No Man Is an Island (colour) (SS-185)
Ontario Visual Education Branch.
The Great Canadian Shield (colour)
Know your Resources
National Film Board, Ottawa.

Film Strips

Asbestos—Mining, Processing

Our Resources—Mining, Part 1

Our Resources—Mining, Part 2

Our Resources—Mining, Part 3 (post-war)
National Film Board, Ottawa.

Gold and Silver (with manual)

Iron and Steel (with manual)

Copper and Its Uses (with manual)
Ryerson Film Service, Toronto.

Canada's Mining Industry
Associated Screen News, Toronto.

UNIT SIX

Forests Are Important to Us: Conserve Them

15. *USING AND ENJOYING OUR FORESTS*

Forests are one of Canada's most important natural resources. They provide raw material for our homes and clothing. Science and industry, working with wood, are creating new industries, new products, new jobs, and new wealth. While trees grow, they conserve wildlife, provide us with beautiful recreation, conserve water and soil, and improve climate. Forests serve us well.

16. *WE MUST PROTECT AND USE OUR FORESTS WISELY*

Our forests belong to future generations as much as to us. They are ours in trust, to be protected and used wisely. We must protect them from fire, insects, and diseases; we must employ wise methods of cutting; we must use their products without waste. These are our responsibilities.

17. *WE NEED MORE FORESTS AND MORE TREES*

Protection and wise use of our existing forests are not sufficient. We must renew the forests that have been destroyed or unwisely cut, leaving unproductive land. This chapter will guide us in this undertaking by showing us how trees live, how to obtain the right kinds of young trees, and how to plant and care for them in new forests, woodlots, and windbreaks.

15

USING AND ENJOYING OUR FORESTS

For the men and women who settled Canada, the forest provided the main necessities of life. From the trees of the forest came their houses and furniture, their fuel, and many of their tools and implements. From the berries and other fruits, and the wild animals and birds, came much of their food. From the cool, clear waters of the forest streams they took fish. They found some trees from which they could make good timbers for boats, and others that provided the tar and pitch to caulk them. From the bark of trees they obtained tannin to tan hides into leather, and dyes to colour their home-made cloth.

Forests are still important to us. Whether we live in the city where trees grow chiefly in parks and along streets, or in the country where green woods are nearer at hand, we will want to know more about Canada's amazing forest story.

A forest is a community of all sorts of living things. Its plant life includes large and small trees, vines and shrubs, and a carpet of flowering plants, ferns, and mosses. Among the forest animals are birds and insects, squirrels and rabbits, and many other animals, large and small.

A forest benefits us today in many ways. We still use its wood to build, furnish, and heat our homes. From it comes some of our food. We enjoy the beauty and cool shade of its trees, the singing of its birds, and the chattering of its squirrels. We breathe its pure fresh air and drink the water from its cool streams.

How different our ways of living would be if there were no forests!

PUPIL INVESTIGATIONS.

Some research on your own will help you to profit more from what you are going to read in this chapter.

Find out:

(a) what parts of Canada are still in forest;
(b) what regions in Canada, or in your province, lead in the production of timber, lumber, and wood pulp;
(c) the location of each provincial and national park in Canada;
(d) what percentage of the world's forests is in Canada;
(e) in what ways people in Canada obtain employment as a result of our forests;
(f) how much of the world's paper is made in Canada;
(g) what kinds of wildlife live in the forests of your province.

Forests Give Us Many Everyday Products

Trees have always provided man with many useful products. The pioneers used the products of the forest largely as they found them, without remanufacturing them. In modern living we combine old uses with new uses: we use the forests somewhat as we did a century ago, but we also take advantage of the many inventions which have shown us new ways of using them. Thus we use the gifts of the forests (1) as products made directly from the trees themselves (primary products); (2) as manufactured articles, but still of natural wood (remanufactured wood products); and (3) as entirely new substances, no longer wood, but made from some part of the tree (artificial wood products).

PRIMARY PRODUCTS OF THE FOREST. The main varieties of Canadian trees used for lumber are spruce, Douglas fir, hemlock, white pine, cedar, and yellow birch. From the trunks

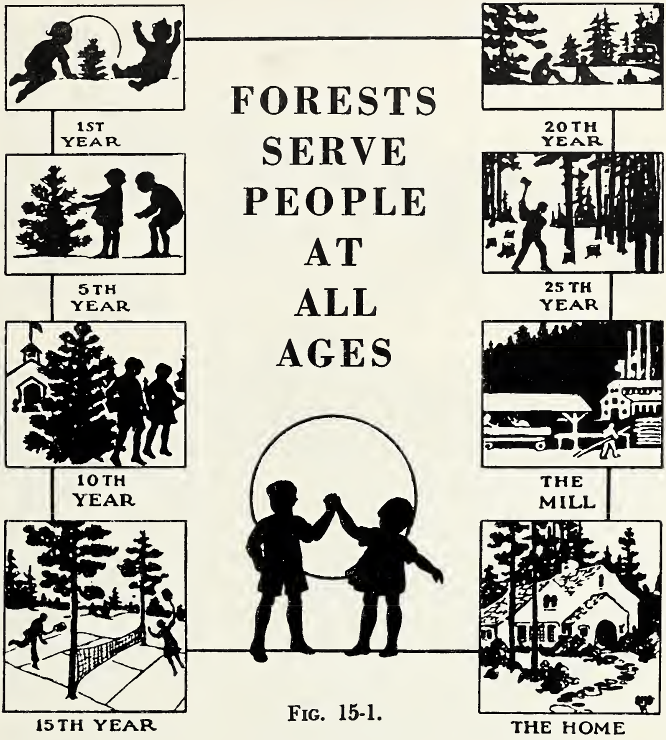


FIG. 15-1.

of trees we make timbers, lumber, posts and poles, railroad ties, and numerous other useful products. By other processes we may change this wood into veneer, plywood, shingles, or excelsior. From both trunks and branches comes firewood, the fuel used in most pioneer homes and still used in many homes today. From many kinds of trees we obtain food in the form of fruits and nuts, or sap which can be made into maple syrup or maple sugar.

The maple sugar industry depends upon the tree's way of living. In spring the sweet sap, carrying stored food, flows up

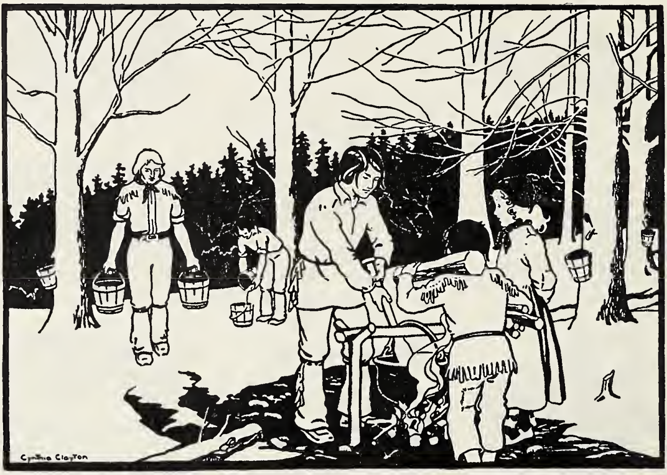


Fig. 15-2. Maple Sugar Time.

the tree to its branches and opening buds. Man taps this line of flow. He drills a hole just through the bark, then he inserts a little metal spout, called a spile, through which the sweet sap runs out into a pail. From the sap, collected daily, he boils off the water until he obtains maple syrup or maple sugar. The early settler used a large iron kettle over an open fire in the woods. Today the syrup producer uses a modern evaporator for this process. To obtain a gallon of syrup, about 32 gallons of sap must be boiled down.

REMANUFACTURED WOOD PRODUCTS. Through the ages man has learned to make many things from wood: some for his use, others for their beauty. In your classroom are many articles which have been manufactured by using lumber, veneer, or other forms of wood: the flooring, trim, and doors; the desks and cupboards; even your pencils. Of course, our hockey sticks and baseball bats are made of wood. Skilled woodworkers have contributed much to man's welfare by building trucks and trailers, wagons and railway cars, ships and barges, seaplanes and aeroplanes, all more or less from wood.

ARTIFICIAL WOOD PRODUCTS. Modern science has enabled us to make from wood new products not even dreamed of by our forefathers. In buildings we use wallboards and other insulating materials, most of which are made from wood. Paper, cellophane, rayon, linoleum, artificial leather, and phonograph records have all been made possible by changing wood chemically into new substances. So have turpentine, rubber, wood alcohol, charcoal, plastics, and many dyes.

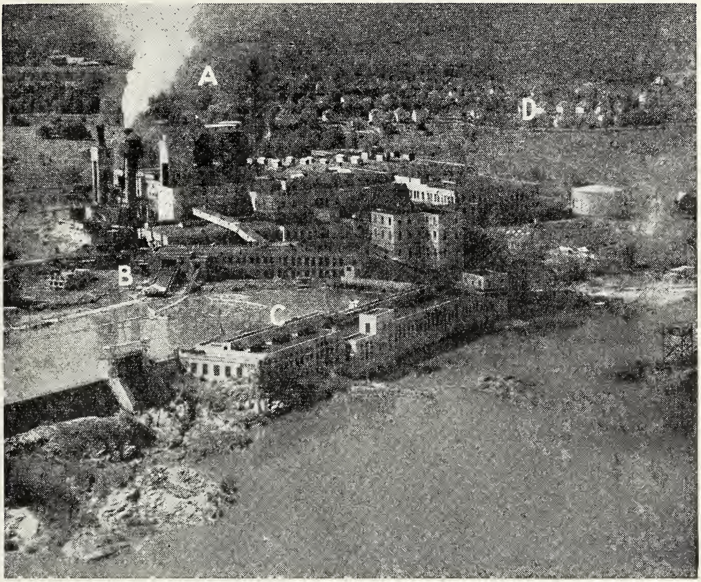


FIG. 15-3. PULP AND PAPER MAKING AT IROQUOIS FALLS.

A, the vast expanse of forest, the source of pulpwood; B, logs entering the paper mill after being taken up the elevator from the log pond; C, the power plant, which uses large quantities of water to make the electricity needed to operate the machinery in the mill; D, the townsite containing the homes of the employees.

In keeping with modern conservation practices, many by-products of sawmills, woodworking establishments, and pulp-and-paper plants, formerly discarded as waste, are now made into useful artificial wood products.

Exercises for Research and Review

1. Investigate these and report your findings to class:

(a) the kinds of trees that produce the shingles, floors, trimmings, doors, window-frames, rafters, and joists of your home;
(b) what foods the forest provides for your table;
(c) the kinds of wood in your furniture;
(d) how the resin of southern pine trees is collected and made into turpentine;
(e) how latex is taken from rubber trees and made into natural rubber;
(f) how tar and charcoal are made from wood;
(g) how rayon is made from wood pulp.

2. Make a large diagram of a tree, showing its root system, trunk, branches, leaves, and fruit. In their proper positions on this diagram, label all the tree products that you can think of. Include such items as rubber, turpentine, oxygen, cork, building materials, fuel, and foods for man and other animals.

3. Make a class chart entitled GIFTS OF THE FOREST. For column headings use such sub-topics as: *From the Trunk, From the Bark, From the Branches, From the Leaves, From the Sap, From the Flowers, From the Fruit*—or headings of your own choice.

Forests Are Sources of National Wealth

Canada's forests have provided much of her wealth. From her early history Canada has both produced and exported large quantities of wood and wood products. In former days she won fame by providing the timbers and masts for the world's greatest ships; today she gains wealth by her exports of pulp and paper.

THE FOREST REGIONS OF CANADA. Canada's forested regions stretch almost continuously from the Atlantic Coast to the mountainous islands of the Pacific. Nearly 60 per cent of

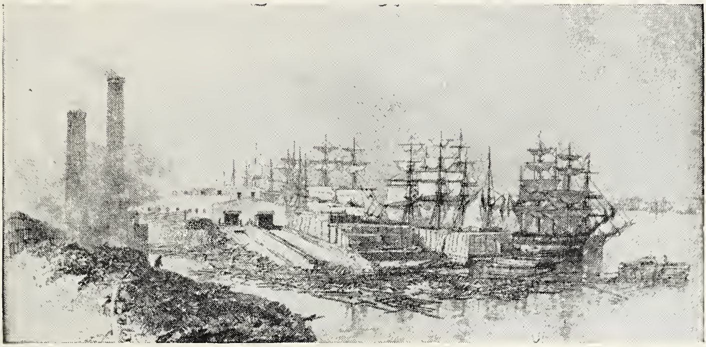


FIG. 15-4. CHATHAM, N.B., IN ITS EARLY DAYS.
While the surrounding highlands were wooded, lumbering was a thriving industry here.

the area of the ten provinces of Canada is forested, providing for every Canadian family of five people about 150 acres of wooded land. Many varieties of trees find favourable growing conditions in some part of Canada: scrub trees in the Far North, marketable evergreen trees over a wide area farther south, and hardwood trees near the southern border. The growth of so many species of trees is made possible by the many types of climate, soil, and surface found in so large an area.

Those who know our forests best have divided Canada into several forest regions, as shown on our map. The trees living in each region thrive under the same growing conditions and, therefore, grow

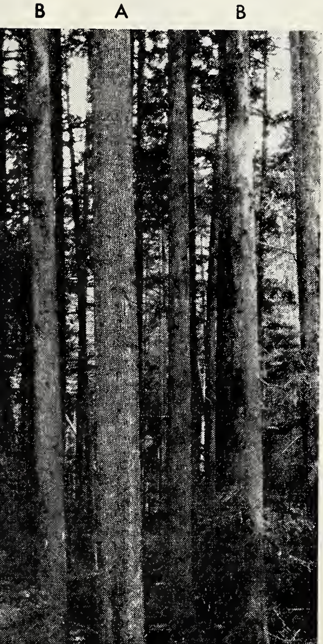


FIG. 15-5. A TYPICAL SCENE IN A BRITISH COLUMBIA FOREST.
A, western hemlock; B, western red cedar.

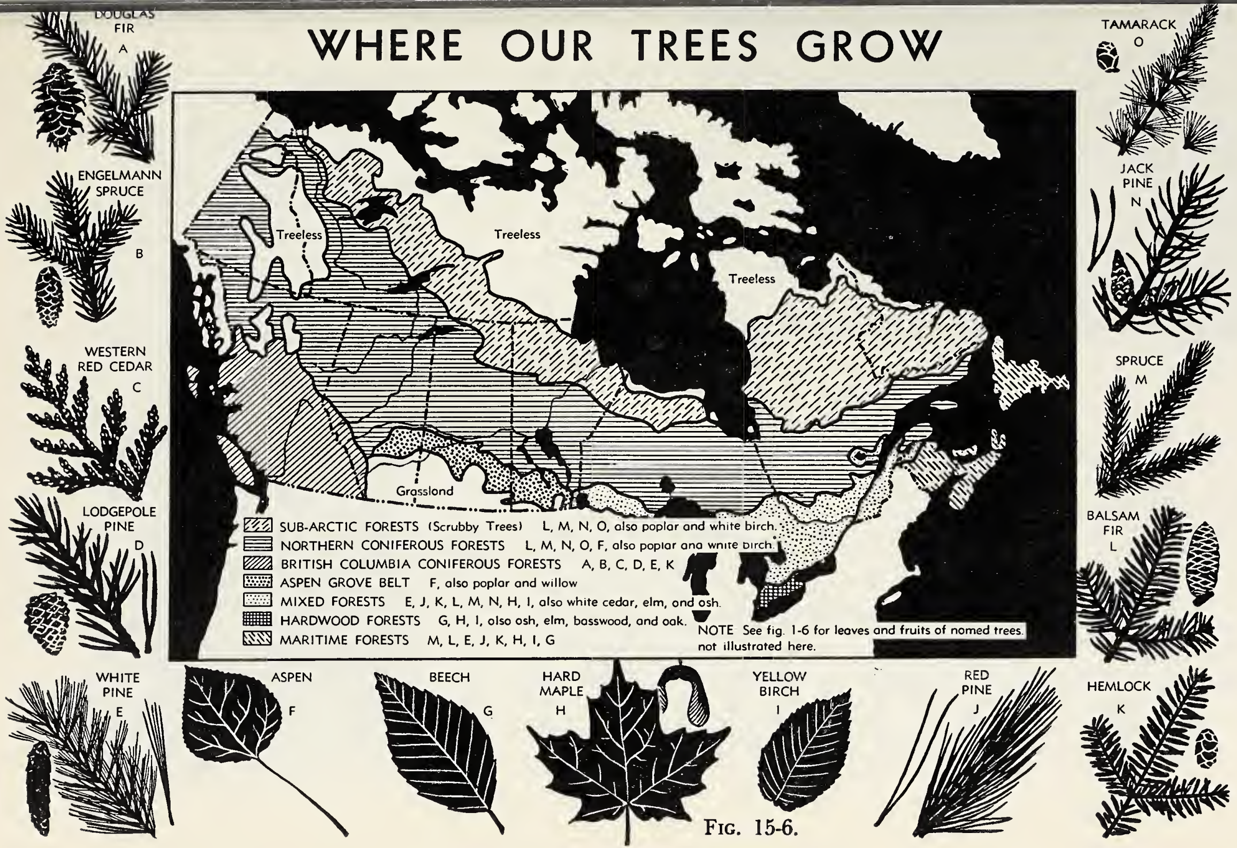

WHERE OUR TREES GROW
DOUGLAS FIR A
ENGELMANN SPRUCE B
WESTERN RED CEDAR C
LODGEPOLE PINE D
WHITE PINE E
ASPEN F
BEECH G
HARD MAPLE H
YELLOW BIRCH I
RED PINE J
HEMLOCK K
BALSAM FIR L
SPRUCE M
JACK PINE N
TAMARACK O
Treeless
Treeless
Treeless
Grassland
▨ SUB-ARCTIC FORESTS (Scrubby Trees) L, M, N, O, also poplar and white birch.
▤ NORTHERN CONIFEROUS FORESTS L, M, N, O, F, also poplar and white birch.
▨ BRITISH COLUMBIA CONIFEROUS FORESTS A, B, C, D, E, K
▦ ASPEN GROVE BELT F, also poplar and willow
▦ MIXED FORESTS E, J, K, L, M, N, H, I, also white cedar, elm, and ash.
▦ HARDWOOD FORESTS G, H, I, also ash, elm, basswood, and oak.
▧ MARITIME FORESTS M, L, E, J, K, H, I, G
NOTE See fig. 1-6 for leaves and fruits of named trees not illustrated here.

Fig. 15-6.

How To Recognize Our Native Evergreen Trees

1. Leaves needle-like
    - (A) Needles in clusters
        - (1) Needles in clusters of five each .... white pine or western white pine
        - (2) Needles in clusters of two each
            - (a) Needles 4″ to 6″ long, shining red pine
            - (b) Needles 1″ to 3″ long, twisted (British Columbia) .... lodgepole pine
            - (c) Needles not more than 2″ long scrub pine or Jack pine
        - (3) Needles in clusters of more than ten each on older branches, but singly placed on the young growth of this year; needles shed in autumn .... larch or tamarack
    - (B) Needles single, not in clusters
        - (1) Needles easily rolled between the thumb and finger; four-sided rather than flattened .... spruce
          (kinds of spruce: white, black, red, and Engelmann)
        - (2) Needles flattened, blunt or round pointed, each on a little stalk .... western hemlock or eastern hemlock
        - (3) Needles flattened, sharp-pointed, each on a little stalk (British Columbia) .... Douglas fir
        - (4) Needles flattened, not having any stalk .... balsam or balsam fir

2. Leaves like little scales completely covering the twig
    - (1) Leaves scale-like, pointed, yellow-green eastern white cedar
    - (2) Leaves scale-like, smaller than on white cedar; fruit a berry .... eastern red cedar or juniper
    - (3) Leaves scale-like, blunt, yellow-green .... western red cedar

together. The trees of the Northern and Maritime Regions are used for newsprint and lumber, those of British Columbia for lumber and structural timbers, and those of the Great Lakes and St. Lawrence Region for lumber, furniture, and flooring. Spuce and balsam are commonly found in the North and in the Maritimes; Douglas fir, red cedar, and western hemlock, in British Columbia; and white pine, hard maple, and yellow birch, in the Great Lakes-St. Lawrence Region.

HOW FORESTS CONTRIBUTE TO CANADA'S WEALTH. From pre-historic times wood has given employment to men. In the Bronze Age and in the Iron Age wood had to be made into charcoal to smelt metals. The early explorers sailed the seven seas in ships made from wood. Pioneer settlers used it to build and furnish their homes and to make their tools and implements.

Our forest industries give employment to more people, and pay more wages, than any other industry in Canada. In Canadian woods more than 150,000 men are employed, cutting the trees and hauling them to streams, trucks, or railways. To change this wood into useful products, many more thousands of men work in lumber industries; pulp and paper mills; industries connected with the making of furniture, vehicles, and agricultural implements; tanneries; chemical plants; industries essential in publishing newspapers, magazines, and books, and hydro-electric plants producing electricity to turn the wheels of these industries. Many people in every city and

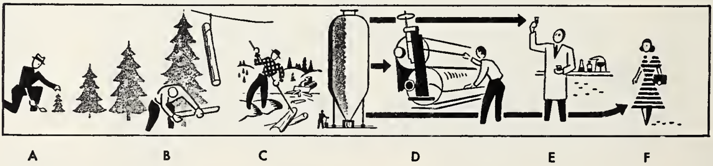


Fig. 15-7. Forests Give Employment to Many People.
A, foresters and forest owners; B, woodsmen; C, loggers; D, employees of pulp and paper industries; E, chemists; F, manufacturers of rayon and other forest products.

town earn a living by helping to construct buildings or transport forest products. This helps us to understand how a million Canadians obtain their living directly or indirectly from our forests, and why more than half a million railway freight cars are used each year to transport forest products.

Forest industries and their employees, like other industries and wage-earners, pay both local and federal taxes. These help to build roads and schools, operate hospitals and playgrounds, and supply other public services upon which all of us depend. How important forests are to everyone!

Things To Do

1. Find out what industries in your community depend upon trees, and what specific products they make.
2. Make a map entitled WHERE WE GROW OUR TREES. On it, name each province, indicate each forested area, and print the names of the important kinds of trees.

Forests Conserve Wildlife and Provide for Recreation

FORESTS CONSERVE WILDLIFE. Our Canadian forests are the natural habitats of wildlife. By furnishing beavers, foxes, and other wild animals with food, protection

FIG. 15-8. A DEER'S PARADISE.
Forest undergrowth provides food and protection for deer.

from their enemies and from winter cold, and with sheltered home sites, the forests have made Canada famous for her fur-trade. For song birds our forests provide shade and shelter, food and nesting places, and protection from their enemies. The birds, in turn, pay for these services by protecting the trees from insects. Fish are most abundant in streams kept cool by the shade of trees. Most wild flowers thrive best under forest cover. Unfortunately, when the forests were cleared from the Southern Ontario Agricultural lands, the beaver and the larger animals had to find homes in the remaining forests farther north. Some larger species, such as moose, elk, and caribou, have suffered, but the deer and foxes like second-growth forests, and also settlers' clearings.

PUPIL INVESTIGATIONS. **Learn about other animals in the forest.**

Observe red squirrels seeking nuts which they hid in the ground in autumn, many of which will remain buried and grow into new trees.

Look on small twigs of wild cherry trees for collar-like masses of eggs of tent caterpillars. Destroy any that you find, to prevent them from hatching into caterpillars which will strip the trees of foliage.

In the forest floor look for earthworms, ground beetles, salamanders, and centipedes. All these help to keep the soil porous.

FORESTS PROVIDE FOR HEALTHFUL RECREATION. Everyone enjoys and reaps improved health from some leisure and recreation — and in what better place can we obtain it than by a lake surrounded by a cool, green forest! Here we may camp, swim, fish, or, if we prefer, paint, take photographs, or enjoy the birds, the wildlife, and the beauty of wild flowers and colourful sunsets. All these opportunities provided by our forests, and the game and fish in them, attract thousands of tourists annually, in both winter and summer. In this manner our forests have assisted the tourist industry, worth millions of dollars a year to Canada.

LET'S ENJOY OUR NATIONAL AND PROVINCIAL PARKS. Canada's system of national and provincial parks is one of the finest and most extensive in the world. Created more than half a century ago, these parks have conserved and protected for our use and enjoyment some of Canada's most beautiful forest, prairie, and mountain areas. Here, much of Canada's original wildlife has been protected under favourable natural conditions. In some of these parks we find deer, elk, moose, bear, and buffalo; in others, fur-bearing animals such as beaver, muskrat, mink, and fox. Parks provide safe homes for wild fowl, song birds, and game fish.

FIG. 15-9. FORESTS GIVE OPPORTUNITIES FOR HEALTHFUL SPORT.

The forest conserves the snow necessary for good skiing.

PUPIL INVESTIGATIONS. Learn more about Canada's national and provincial parks.

Write to the National Parks and Historic Sites Service, Ottawa, and to your provincial government for literature describing the national and provincial parks in your province.

Forests Improve Climates and Water Supplies

Forests make the atmosphere more healthful and the surrounding farm areas better places in which to live. Let us find out how they do this.

FORESTS MAKE OUR WEATHER AND CLIMATE MORE HEALTHFUL. Trees help to purify the air we breathe. They remove from it some of the carbon dioxide we breathe out, and use it for food. Then they replace this carbon dioxide with oxygen, making the air more healthful for us and other animals to breathe.

Forests improve the climate of places near them. The millions of leaves in a large forest give to the atmosphere many barrels of water daily. This makes the atmosphere more humid and, therefore, more healthful. Sooner or later the moisture must fall as rain. Thus, large forests increase the rainfall in the surrounding regions and help to prevent long periods of drought and their injurious effects on crops.

Forests moderate the temperature in and around them. Leaves cut off the warming rays of the sun, leaving the temperature several degrees lower in the shade beneath them than elsewhere in the vicinity. A dense forest has a much greater cooling effect than an individual tree that shades us, our home, or cattle in a field. Trees, especially evergreens, break the force of cold winds in winter, thus giving wooded areas a more moderate temperature.

FORESTS MAKE FERTILE SOIL. When the pioneer farmers cleared the forests from the level lands in Eastern Canada, they found comparatively fertile soil. This had been made richer by the accumulation of humus and mineral elements left by the decay of leaves and branches over a long period of time. However, the soil formed under forests is not nearly as deep or as good for agriculture as that formed on the Prairies, where topsoil may reach a depth of five or six feet.

Fig. 15-10.
Forests Make Fertile Soil.
This handful of rich forest soil contains the decayed remains of leaves and twigs.

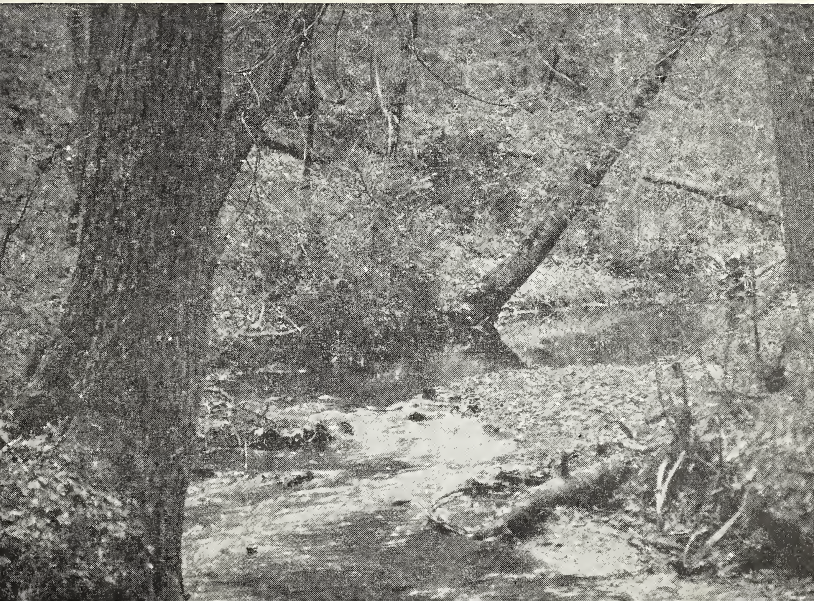
The best farms in Eastern Canada are found on the cleared land in level river valleys and in areas with low, rolling hills. Unfortunately, a great many forests were removed from land that never should have been cleared for agriculture at any time. These rocky, sandy, or thin-soiled areas are now abandoned farms, and are being replanted to put back the forests that once grew there so well.

FORESTS HELP US TO CONSERVE WATER AND SOIL.

Forests Store Water for Summer Use. Forests are our best storage reservoirs for water. In chapter 7 we learned how well the forest floor, with its decaying leaves, leaf mould, and humus, all serving as a huge sponge, holds large quantities of water. The water from melting snow and spring rains is caught and held in this layer. Some of this water is taken in by the trees for food during the spring and summer; much of it gradually

FIG. 15-11. A FOREST-FED STREAM.

Forests absorb and store enough water to keep streams like this flowing the year round. Such clear streams, kept cool by the shade, are ideal for trout.



seeps deeper into the soil where it becomes ground water and raises the level of the water table in the surrounding region.

This increased supply of ground water, trapped by the forests, serves us in several ways, especially in dry summer weather or in other periods of drought. Some of it comes up close to the surface and feeds our crops. Some of it keeps our wells and farm ponds supplied with water, becoming useful for domestic purposes or for farm livestock. Some of it comes to the surface in springs, perhaps feeding little streams that flow from the forest and fill nearby creeks, then rivers, keeping them flowing throughout the summer. Some of it fills our marshes and swamps and helps to keep them suitable habitats for wildlife. When our forests go, so also does the water needed for our homes and our stock and for useful wildlife. We must conserve and care well for our forests.

Forests Help to Prevent Floods and Erosion. When more water flows through a valley than the stream channel is capable of carrying, some of it must overflow the stream banks. This causes a flood. Floods usually occur in spring when water collects from fast-melting snow and from spring rains more rapidly than the streams can carry it away. Forests help to prevent such floods by delaying the melting of snow and by absorbing more water than bare soil can take in. In chapter 7 we learned more about the causes of floods, how they do harm, and how forests help to prevent them. Let us re-read the sections there entitled "Forests and Other Vegetation Trap Raindrops" and "Floods Must Be Prevented".

Erosion is the wearing and carrying away of soil by wind and water. Only the water that flows over soil can erode it. Therefore, forests help to prevent erosion by causing the water from melting snow and from heavy rains to soak into the soil rather than run off from it. Even when some water does run from a steep slope in a forest, the dead leaves covering the surface of the forest floor, and the network of roots in the soil, prevent the running water from loosening and carrying away the soil. For these reasons, the water in forest streams is usually clear, not muddy like that from cultivated or bare soil.

Forests help to prevent erosion by wind in two ways. The tops of the trees break the force of the wind, and the layer of litter on the forest floor keeps the moving air from disturbing the soil. Because the thick growth of mature and young trees in a natural forest prevents the wind from sweeping through, it both helps to keep the soil moist within the woods and protects the farm land beyond it from the injurious effects of strong winds.

To conserve both soil and water, we must keep hilltops and steep slopes covered by forests.

When We Plant a Tree[1]

What do we plant when we plant a tree?
We plant a home that is to be—
A ship to sail across the sea—
A desk, a chair, a book maybe—
These we plant when we plant a tree.

What do we plant when we plant a tree?
Beauty and joy for all who see—
A home for birds to bide a wee—
Grateful shade for you and me—
These we plant when we plant a tree.

WARREN P. LANDERS

Things To Do

1. Make a collection of tree products. Label each, and attach a short story about it.

2. Make a scrapbook in two halves, the first showing the uses of trees and their products one hundred years ago, the second showing the corresponding uses today.

3. Collect and mount pictures showing how forests give profitable employment to people.

---

[1] By permission of "The Congregationalist (now Advance)".

4. Arrange a class period in which one pupil represents each of the following and expresses his concern about forests: a farmer, a manufacturer, a fisherman.

5. Explore steep slopes in forests and equally steep cultivated slopes to discover which shows more evidence of erosion.

6. Find out how forests prevent erosion. Build a mound of soil outdoors or on a sandtable. Cover one side of it with moss and leaf mould to represent a forest floor; leave the other side of it bare. Sprinkle equal amounts of water on each side of it to represent rain. From which side does more water run off? From which side is the water more muddy? Why?

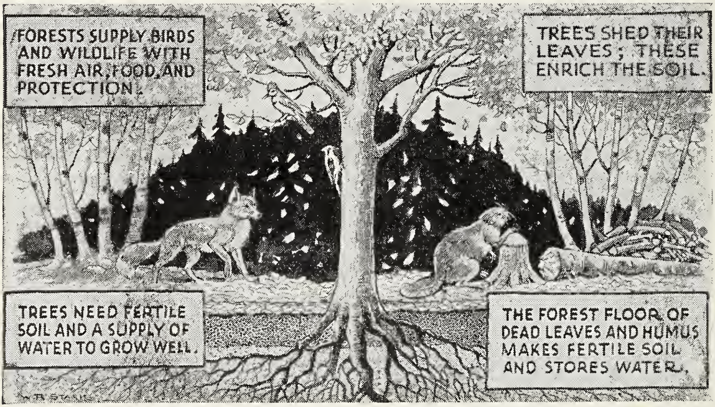

FORESTS SUPPLY BIRDS AND WILDLIFE WITH FRESH AIR, FOOD, AND PROTECTION.
TREES SHED THEIR LEAVES; THESE ENRICH THE SOIL.
TREES NEED FERTILE SOIL AND A SUPPLY OF WATER TO GROW WELL.
THE FOREST FLOOR OF DEAD LEAVES AND HUMUS MAKES FERTILE SOIL AND STORES WATER.

FIG. 15-12. FORESTS ENRICH SOIL, STORE MOISTURE, AND PROTECT WILDLIFE.

A Review

Study fig. 15-12, then tell what parts of this chapter are reviewed by it.

Topics for Discussion

1. How forests improve the three things we need most: air, water, and soil.

2. How forests add to our health and fun.

3. The harm done by sediment in flood waters to: fish, water plants, harbours, artificial ponds or reservoirs.

4. The value of forests to man as a source of lumber.
5. The importance of forests in preventing: floods in spring, the drying up of streams in summer, loss of fertile topsoil by erosion.
6. How forests help wildlife.
7. The value of our national parks to Canada.
8. Whether we could live without forests.

Write Answers to These

1. Name some of the major industries that depend upon forests, and tell how each industry contributes to the welfare of man.
2. State three reasons why Canada has so many varieties of trees.
3. Name four provinces in which forests are important. Name three of the main kinds of trees in each.
4. State two ways in which our Canadian forests help (a) to bring business to transportation industries, (b) to pay for goods that we import from other countries, (c) to build our country's defences.

* * *

Read

Compton's Pictured Encyclopedia: "Turning Forest Trees into Lumber", Vol. 8, pp. 340-351.

16 mm. Sound Films

Maple Sugar Time (SN-48)
The Forest Producers (SG-41)
Arteries of Life (SG-39)
Nature's Engineer (SN-101)
Paper (SN-58)
Newsprint (SS-182)
Paper Making (SN-59)
Ontario Visual Education Branch.
Your Forest Heritage (colour)
National Film Board, Ottawa.

Film Strips

Sweet Sap
Timber—from Forest to House
Native Trees of Canada (east of British Columbia)
Native Trees of Canada (British Columbia)
National Film Board, Ottawa.

Pulp and Paper Industry in Canada
Associated Screen News, Toronto.

Telling Trees Apart (colour) (with manual)
Our Forests and What They Mean to Us (with manual)
Friends of the Trees (with manual)
Ryerson Film Service, Toronto.

The Wealth of the Nation (colour)
Abitibi Power & Paper Company, Limited, 403 University Avenue, Toronto.

16

WE MUST PROTECT AND USE OUR FORESTS WISELY

OUR FORESTS SERVE US WELL. They give us lumber to build our homes, other products for everyday use, employment to earn a living, and healthful recreation. They serve us, too, by providing useful wildlife with food, shelter for their homes, and protection from their enemies. In times of drought they keep our springs and rivers flowing, and our fields and wells supplied with water. Forests can continue to serve us in these ways only so long as we protect them from their enemies and use them wisely.

Yes, forests have their enemies, just as people or grains and vegetables have theirs. The most harmful enemies of forests are fire, insects, tree diseases — and man. In this chapter we shall learn of the harm done by these enemies, and how we can help to protect the forests from them.

Pupil Investigations

1. Obtain from the Department of Land and Forests for your province the following:

(a) copies of all laws and regulations designed to help to prevent forest fires, lead to wiser use of forests, and regulate the use of crown timber and privately owned forest lands.

(b) a list of all available publications to help in the study of forest conservation.

2. Investigate the work of each of the following divisions of your Provincial Department of Lands and Forests, and report your findings to your class: Air Service, Fish and Wildlife, Forest Protection, Recreational Areas, Reforestation, and Timber Management.

Think of These Facts

1. The estimated average loss of timber and other property caused by forest fires, per year, from 1940 to 1949,

in Canada	$4,261,000
Actual cost of fire fighting per year	$1,314,000
Total annual loss	$5,575,000

This value shows only the actual sale price of the standing trees, which is usually only a fraction of the price of the finished lumber in the yard. In addition, the damage to the soil by burning and by the erosion which follows the fire, the reduction in the amount of water that can be stored in the soil, and the injury to wildlife are not included in this estimate. If they were, the total would be a very much greater figure. The total damage caused by forest fires would be many millions of dollars more than the five and a half million dollars shown. No one can accurately estimate the loss in years of time, or the costs of growing a new forest from burnt land or areas where heavy fires have destroyed everything down to the bare rock.

2. The wastage of our Canadian forests, per year, from 1939 to 1948, was as follows:

By forest fires	228,266 thousand cu. ft. (6.7% of all forest materials used up)
By insects and diseases	500,000 thousand cu. ft. (14.6% of all forest materials used up)
Annual waste of forest products by fire, insects, and diseases	21.3% of all forest materials used up

Forest Enemies

FOREST FIRES. "An hour of fire can destroy a century of growth." When fire strikes a forest, all is lost — its beauty, its commercial values, its wildlife, its value in conserving water and soil. One fire can destroy a forest that has taken centuries

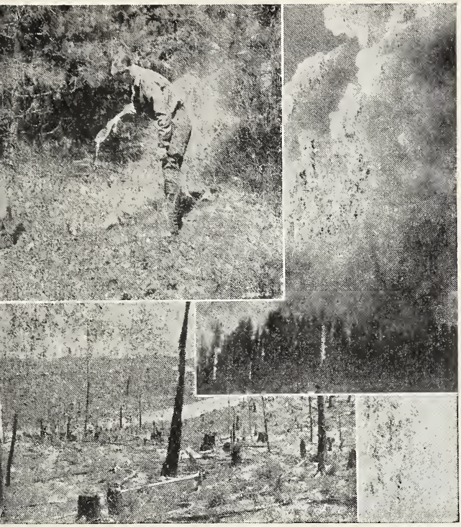


Fig. 16-1. Fire—Enemy of the Forest. If your camp-fire (*top left*) is not put out completely, it may start a forest fire (*top right*) and cause a desolate waste like the one shown here.

to grow, leaving standing only a few charred stubs of large trees. Fire kills or drives away all animal life: bird, beast, and fish. A forest fire leaves behind it a desolate waste (fig. 16-1). The wounds of trees that do not die are readily attacked by insects and diseases (fig. 16-2). Young trees, seedlings, and seeds that would make the forests of tomorrow, perish. Forest fires often burn from the soil the humus that the forests have taken thousands of years to make, and that is necessary for either trees or other crops to grow. The soil that remains on a burned-over area lies unprotected, ready to be carried away by wind or water.

Causes of Forest Fires. Man's carelessness is the greatest cause of forest fires. A cigarette or a burning match thrown carelessly away, or a campfire left smouldering, may

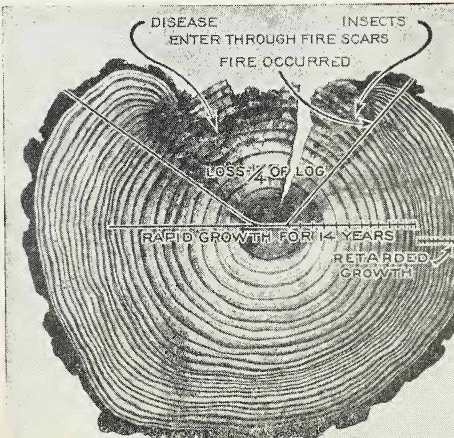


Fig. 16-2.
How Fire Ruins Timber.
Fire burned the bark of this tree in its 14th year. After that, growth was less, and disease and insects entered through the fire scar.

start a blaze which will spread, if uncontrolled, over thousands of acres. Other causes of forest fires are: the burning of brush when the surroundings are dry, sparks from railway engines, and lightning. The danger of forest fires is greatest on dry days in May and in autumn when the forest floor is covered with dead leaves and the trees lack foliage, also on dry, hot, windy days in summer.

Prevention of Forest Fires. Preventing forest fires is better than controlling them. It is also much easier. The following simple rules, if followed, would prevent almost all forest fires:

Fig. 16-3.

(1) Break a used match before throwing it away. This makes certain that it is "out".

(2) Be sure that stubs of cigarettes and cigars are "out" before throwing them away.

(3) Build campfires on sand or on mineral soil and at a safe distance from dead leaves and twigs — then be sure there is not a spark alive when you leave. Always use twice as much water as you think is necessary to drown the fire. Always leave black charcoal, which is formed when water is poured on hot burning sticks or logs. White-coloured ashes show that someone was careless and did not drown the fire with water.

(4) Burn brush only when forests are wet and when there is no wind — and be sure to get a permit to do so if your provincial laws require it.

Detecting and Putting Out Forest Fires. Though we cannot prevent all forest fires, we can take steps to discover them as soon as they start burning, and to control them speedily.

First we should learn what conditions cause things to burn, and what conditions prevent things from burning. Any wood, surrounded by air, will start to burn as soon as it becomes hot enough; neither a flame nor a spark is needed. It will stop burning as soon as it has cooled enough. Therefore, pouring water on a fire puts it out for two reasons; the water cools the wood below the temperature at which it can burn; steam from the first water applied to the fire drives away the air which is necessary for it to burn.

The Forestry Departments of our governments have planned well to detect and control forest fires. Detailed maps of forest areas have been made from aerial photographs. High observation towers scattered through these areas are each equipped with an observer and a special instrument called a *fire-finder* to detect the first wisps of smoke. At the first sign of fire the observer notifies the fire fighting crews by telephone or radio. Seaplanes and other aircraft patrol the forests to detect and report fires. See fig. 16-4.

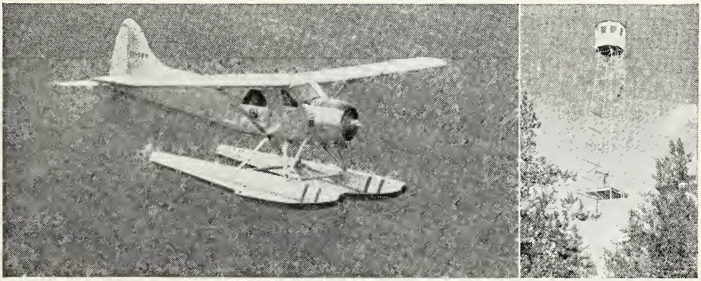


Fig. 16-4. Detecting Forest Fires.
Left, a Beaver aircraft in flight over Sudbury; *right,* a lookout tower in Northern Saskatchewan.

When the exact location of the fire is known, it is marked on a map. Men and fire-fighting equipment are then rushed to the scene by planes, motorboats, railway, motor cars, or other means.

Forest fires are put out or kept from spreading by several methods. Portable power pumps, connected with long lines of hose, are used to throw water from lakes onto fires. Axes, shovels, tractors, fire ploughs, and even water tanks on the backs of men play a part. You should discover how these implements are used.

A fire may be prevented from spreading by cutting the trees from a strip of forest wide enough that fire cannot jump across it, or by digging a ditch to prevent fire from spreading along the ground. Either of these is called a *fire lane.*

Of Interest to All of Us

1. Since Confederation, fires have destroyed six times as many trees in Canada as have been cut.

Fig. 16-5.

2. In such heavily forested countries as Sweden and Czechoslovakia forest fires are very rare — a tribute to the way the people in those countries have learned to care for their forests.

3. We should all take every precaution while camping, hiking, and travelling to see that we do nothing that can start a forest fire.

4. Learn about the work of forest rangers; then try to encourage others to support all steps taken by governments, forestry associations, and conservationists to prevent forest fires.

5. Find out about the clubs of Junior Forest Wardens, the School Forestry Information Clubs in

British Columbia, and the Forest Rangers Schools in Ontario and New Brunswick.

INSECT ENEMIES OF FORESTS. Forest insects destroy millions of cords of timber every year. Some of these insects have always been with us; others have been brought from distant lands, then they spread through our forests. Unfortunately, we seldom notice these pests until they have multiplied and attack in large numbers.

Tent caterpillars frequently attack forest trees in such hordes that they devour the foliage from hundreds of acres of trees. Without leaves, the trees cannot make food. If they do not die, at least they are weakened for two or more years.

In recent years the *spruce budworm* (fig. 16-6), by feeding upon opening buds, has killed enough fir and spruce trees in New Brunswick, Quebec, and Ontario to cause the loss of millions of dollars worth of lumber, wood pulp, and fuel. During the same period of time the *spruce sawfly,* from Europe, has destroyed the spruce trees over thousands of square miles. The *larch sawfly* has caused the death of most of the tamarack trees in some areas. The *white pine weevil,* attacking the growing tips of white pine twigs, causes the needles to turn brown and the top twigs to die. Years later the affected trees will produce only crooked logs, of low grade for lumber.

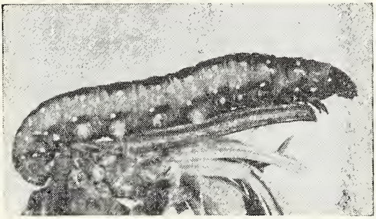


FIG. 16-6.
A SPRUCE BUDWORM LARVA.

Bark beetles, boring under the bark, have caused the death of many pine and spruce trees. Other borers make tunnels in both lumber and logs, making them useless commercially. More recently, the *gypsy moth* has attacked and is doing serious harm to the forests in some areas.

Nature helps to control insects injurious to forest trees. Woodpeckers clamber about the trunks and larger branches of trees, drill into the bark and wood, and remove boring insects. Nuthatches and tree creepers search out the insects that live in the crevices of bark. Chickadees devour the eggs of tent caterpillars. Orioles, vireos, and kinglets inspect twigs and leaves for insect prey. Assisting the birds are some beneficial insects, both large and small, which prey upon injurious forest insects.

The Federal Government, Provincial Forestry Departments, and some private industries help to prevent attacks of insects on our forests. They teach better ways of managing the forests. They prevent the spread of insects by cutting trees when mature and by removing and destroying infected trees or branches; they kill existing insects in the forests by spraying them from the air with insecticides. See fig. 16-7.

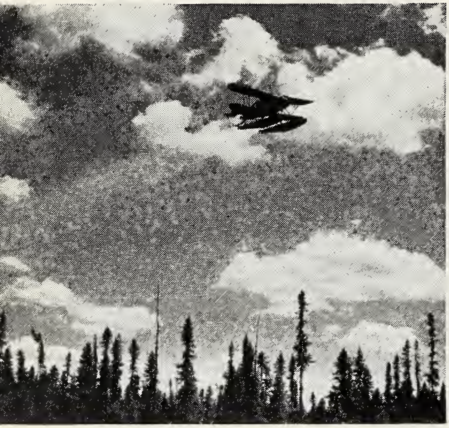


FIG. 16-7. SPRAYING A FOREST TO CONTROL INJURIOUS INSECTS. This low-flying aircraft is spraying a mist of deadly D.D.T. on spruce trees infected with spruce budworm.

TREE DISEASES. Trees, like people, are subject to diseases which either weaken them or kill them outright. Some tree diseases attack only trees that have been weakened or injured, perhaps by fire. Others occur as epidemics and attack all trees in their path.

Very likely you know the *bracket fungus*, shown in fig. 16-8. This is the fruit of a disease of trees or stumps. It starts by means of a small seed-like thing called a *spore* getting into an injured place on a tree. As this fungus disease grows, it takes food from the wood of the tree, and gradually causes its decay.

We may protect trees from this disease by keeping them from being injured and by protecting their wounded places by means of paint. If we remove the diseased trees before the fungus can produce its spores, we shall save other trees. There is one good thing to be said for bracket *fungi* (plural of fungus): they cause broken branches and fallen trees lying in the woods to decay and become useful humus in the soil.

The *chestnut blight* has almost wiped out the last of our nut-bearing native chestnut trees. You may have seen white pine trees with dead branches and yellow needles among the green foliage. This is the result of *white pine blister rust*. This disease caused serious loss to white pine trees until it was discovered that it could not spread directly from one pine tree to another, but must live between times on currant or gooseberry bushes. By destroying these bushes near white pine trees, the disease has been partially controlled.

Dutch elm disease, which has killed many beautiful white elm trees, was introduced accidentally from Europe on logs which were imported for veneer. The disease is carried from one tree to another by a small bark beetle which carries the spores of this fungus from infected trees on which it has been feeding. The disease may be checked by removing and burning diseased trees or by sprays which prevent the bark beetles from feeding on elm trees.

Some tree diseases are controlled by destroying infected trees, or by cutting away their infected parts. Chemicals that kill the diseases are

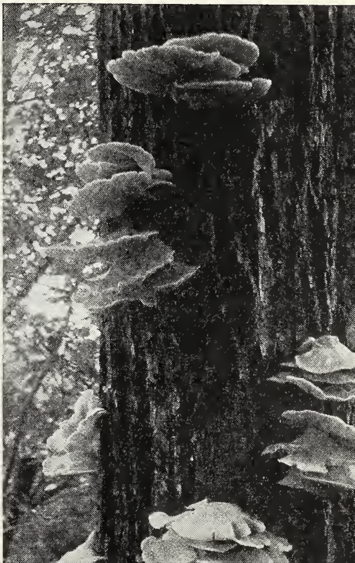


FIG. 16-8. BRACKET FUNGI ON ELM STUB. These plants cause wood to decay.

sometimes sprayed on infected forests from aeroplanes (fig. 16-7). Because diseases are more likely to attack old, weakened trees, these should be kept cleared from forests.

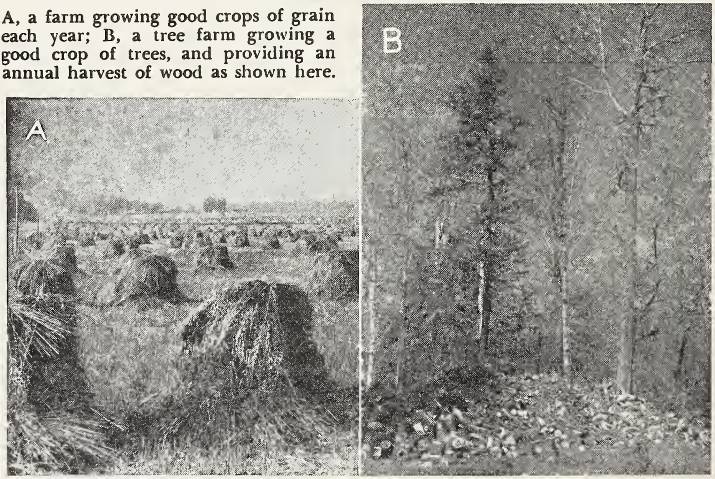
A clean forest, containing only healthy, fast-growing trees, is our best safeguard against fire, insects, and diseases. Therefore, we should learn and practise the best ways of managing our forests, just as we do other crops.

Conserving Forests by Wise Management

"Forestry is the preservation of forests by wise use."

It is only fair that we should conserve our forests efficiently so that they will serve future generations as well as they serve us. The people in many European countries have done this for centuries. One large forest in Sweden has been so wisely managed that it has grown richer with each generation for seven hundred years, although it has produced a continuous harvest of trees and other forest products throughout that time.

FIG. 16-9. TWO KINDS OF FARMS. A, a farm growing good crops of grain each year; B, a tree farm growing a good crop of trees, and providing an annual harvest of wood as shown here.



To conserve our forests we must not only protect them from fire, insects, and diseases; we must manage them as wisely as we would field crops. See fig. 16-9.

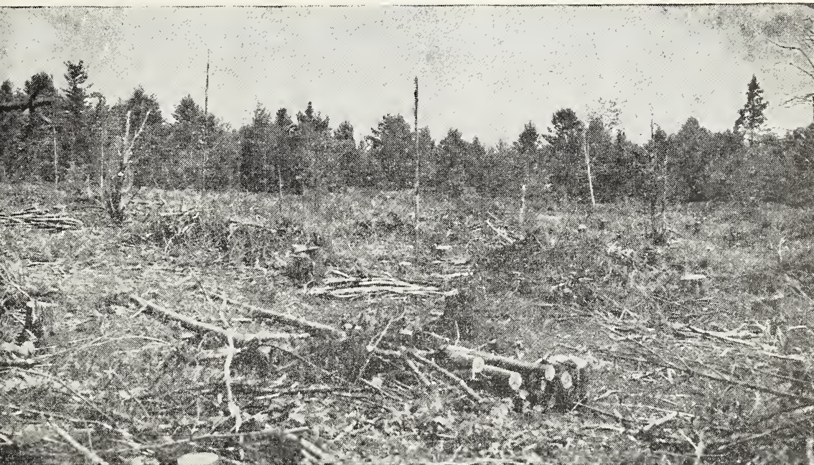
A forest is like a herd of cattle on a farm. The herd, if properly managed, continues to thrive year after year. Young stock constantly replaces those slaughtered or sold. In a properly managed forest, young trees are continually growing up to replace those removed by cutting, diseases, and old age. If we manage forests wisely, it will not be necessary for us to plant new trees; nature will do that.

WISE METHODS OF CUTTING IN FORESTS. Two methods of cutting forests are used, *clear cutting* and *selective cutting.*

If clear cutting does *not* remove all trees, old and young, from a forest, young trees and seed trees are left to produce another crop. However, if land too steep, too stony, too wet, or too sandy for agriculture is *completely* cleared of trees, it may remain unproductive for from 50 to 100 years. It may even be made into barren waste by erosion. Study fig. 16-10.

FIG. 16-10. CLEAR CUTTING A FOREST.

Tree-cutting by-laws in many counties of Ontario now forbid such wasteful clear cutting of immature timber. No young trees are left to produce future crops.



Selective cutting means cutting only selected trees each year, or from time to time. As a result, the forest remains a growing crop from which a harvest of forest products may be reaped continuously. The trees to be cut are all selected for some special reason: because they are mature, or injured, or diseased, or harmful to other trees in some way (fig. 16-11).

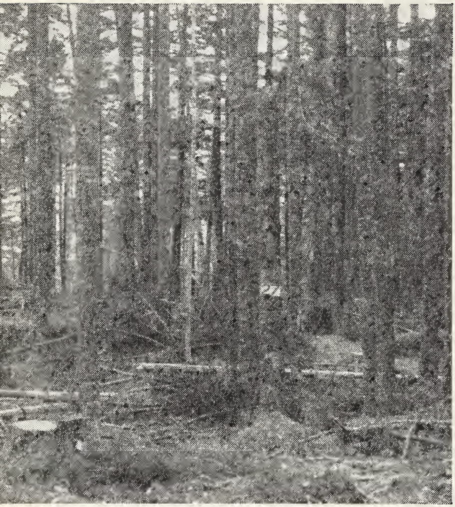


Fig. 16-11.
Selective Cutting of a Forest. Foresters mark the trees that should be cut.

Dead and diseased trees should always be cut from forests to give both space and protection to healthy trees. As a forest grows older, the trees become larger and overcrowded. Some should then be cut to thin out the forest and give more light, moisture, and food to the remaining trees. Wood and lumber are more valuable when obtained from mature trees, which no longer make much growth, but which have not yet begun to decay.

When too many trees are cut, the remaining trees produce large side branches instead of straight, tall trunks from which the best lumber, free from knots, may be cut later. Of course, all trees should be felled in a manner that will not injure remaining trees and seedlings unnecessarily.

WE ALL WORK TOGETHER TO CONSERVE FORESTS. Forest conservation is helped by dominion and provincial governments, by colleges of forestry and agriculture, by forestry associations, by companies that produce lumber or pulp and paper, and also by individual men and women, and boys and girls, like ourselves. Forestry branches of our governments conduct experiments to find the best means of managing forests and of protecting them from their enemies. Then they make this information available, usually without charge, to all who wish to have it.

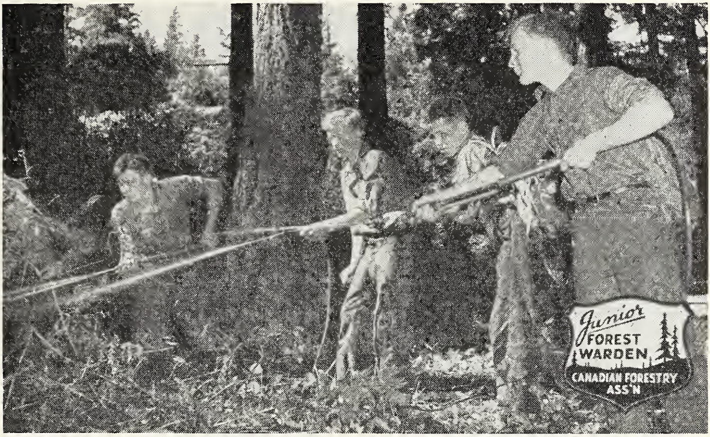


FIG. 16-12. JUNIOR FOREST WARDENS.
These boys are using pack pumps to control fire at a Junior Forest Warden's Camp in British Columbia.

Forestry and agricultural schools train experts to help both governments and private companies to protect and use forests wisely. Large companies, whose future success depends upon continued growth of new forests, do all they can to help make the cut-over land produce other crops of trees. See fig. 16-12.

In the next chapter we shall learn the importance of protecting our forests from grazing animals.

WE SHOULD CONSERVE OUR FOREST PRODUCTS BY USING THEM WISELY. Only about 42 per cent of a tree becomes lumber; 20 per cent is left in stumps and branches; and the remaining 38 per cent is made up of bark, sawdust, slabs, and board trimmings. New discoveries are teaching us better uses for the wasted parts. This is conservation.

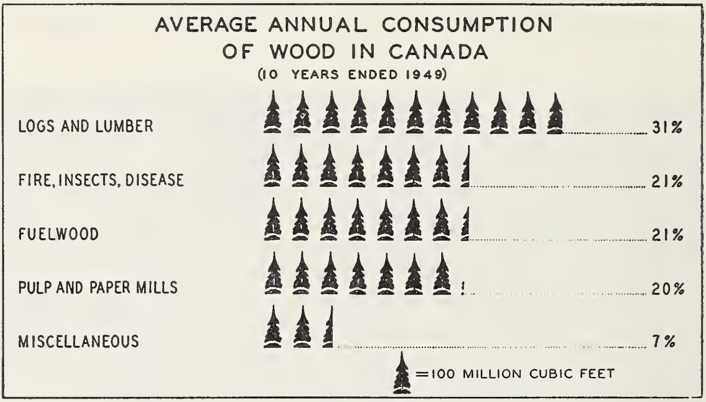


Fig. 16-13.

Some Learning Activities

1. The following information was given by the Forestry Branch of the Canadian Department of Resources and Development, Ottawa, for the years 1939-1948. The numbers indicate percentages of the total value of tree materials taken from our forests. Organize this information into a table under the heading: HOW OUR FORESTS ARE BEING USED UP.

Products which are used: logs and bolts 30.7%; pulpwood 23.8%; fuelwood 21.2%; railway ties .3%; pit props for mines .6%; poles, posts, and rails 1%; other products 1.1% total 78.7%.

Wastage of forests: by forest fires 6.7%; by insects and diseases 14.6% — total waste 21.3%.

2. Visit the nearest office of the Canadian Forestry Association and ask for booklets, bulletins, and posters on forest conservation. If you are not living in a provincial capital city, you might write to the head office at 4795 St. Catherine Street West, Montreal 6, P.Q.

3. Take field trips to some of these: (a) to forests to see proper cutting practices, how fires are prevented, how diseases are recognized; (b) to forest industries or conservation organizations.

4. Interview one of these: elderly settlers, to discover how forests have changed during the past decades; forest rangers, to learn about their work.

5. Make a table or a graph to show these facts concerning the causes of forest fires in Canada: smokers 20.2%; campfires 15.7%; settlers 11.9%; railways 10.3%; incendiary 3%; other man-made causes 13%; unknown causes 6.8%; lightning 19.1%. What percentage of these causes is preventable?

6. Make posters to illustrate conservation of forests. Fig. 16-14 suggests some ideas.

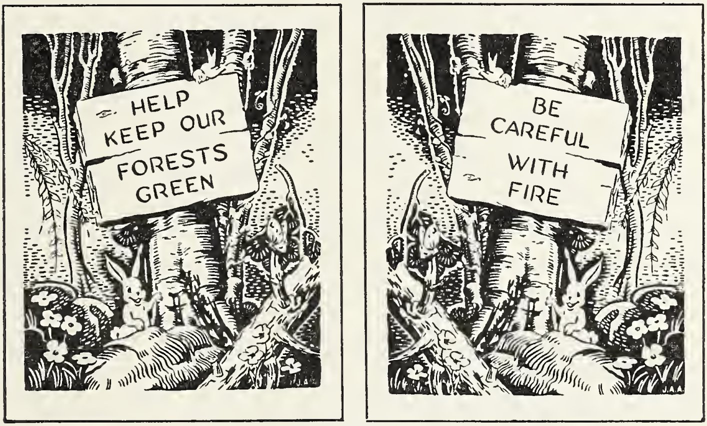

HELP KEEP OUR FORESTS GREEN
BE CAREFUL WITH FIRE

Fig. 16-14.

Solve These Problems

1. From 1940 to 1949 more than 2,000,000 acres of forest land in Canada was burned over each year. How many 100-acre farms does this represent? If the average farm of this size gives a home and a living to five people, what population could be supported on a farming area equal to this area of burned-over land?

2. It is estimated that forest fires in Canada destroy forest and other property to the value of about $4,000,000 per year, and that the cost of fighting them is $1,500,000. How many refrigerators at an average cost of $300 could this money buy? How many automobiles at $2,500 each?

Topics for Talks or Debates

1. Fire, the Forest's Number-one Enemy!

2. Resolved that governments should control or regulate the cutting of trees on private property.

◆

Read

Compton's Pictured Encyclopedia: "The Life-Giving Woodlands and Their Foes", Vol. 5, pp. 236-241.

16 mm. Sound Films

Timagami Ranger (SN-92) (colour)

Forests and Conservation (SN-30) (colour)

One Match Can Do It (H-15)
Ontario Visual Education Branch.

Unto the Hundredth Generation

Look to the Forest

Fighting Forest Fires with Hand Tools (colour)
National Film Board, Ottawa.

Forests and Conservation
Associated Screen News Limited, Toronto.

Film Strips

Using Our Forests Wisely (colour)

Enemies of the Forest (with manual)
Ryerson Film Service, Toronto.

17

WE NEED MORE FORESTS AND MORE TREES

THREE HUNDRED YEARS AGO most of Canada was covered with trees. Like all living things, they grew, matured, died — but there were always young trees beside them to take their places. The dead and decaying remains on the ground beneath them trapped the rain and fed it out gradually to springs and streams. Floods seldom disturbed nature or man; fish abounded in the cool, clear waters; hordes of water fowl, game, and fur-bearing animals made the forests their homes.

Settlers came and changed much of this story of forest life.

When the pioneers first settled on the land, they burned millions of board feet of timber that they did not need for buildings or implements. Too often they cut the forests from land too steep, too stony, too sandy, or too wet for agriculture, and left no young trees to make new forests. In two or three generations many thousands of square miles of land that had once been covered with thriving forests became eroded hillsides, deserted fields, or sandy wastes. Streams become flooded in spring and dried up in summer. Wells became dry. Fish and wildlife became more and more scarce.

It took many years for us to learn the errors of our ways! We looked for remedies for the harm we had done. This was the beginning of the planting of new forests.

WHY WE SHOULD PLANT MORE TREES. Much of the land in Canada that has been cleared of forests should be planted to trees again. Otherwise it will remain unproductive, for it cannot grow any other vegetation. We should reforest such areas for several reasons: to prevent further loss of fertile topsoil through erosion by water and wind; to produce a crop of trees from which we may obtain timber, poles, fuel, Christmas trees, and other valuable products; to provide food and shelter for wildlife; and to create new recreational areas. Some areas that we should reforest are: badly eroded hillsides; sandy regions; hilltops and hillsides that are difficult to work and are likely to become eroded; land that is too rough or too wet to be cultivated for agricultural crops; and forest openings that are not reseeding naturally.

HOW A TREE LIVES. Spring is a good time to learn about the life of a tree and of a forest. It is then that trees are most active.

A tree is an ordinary green plant, having three main parts: roots,

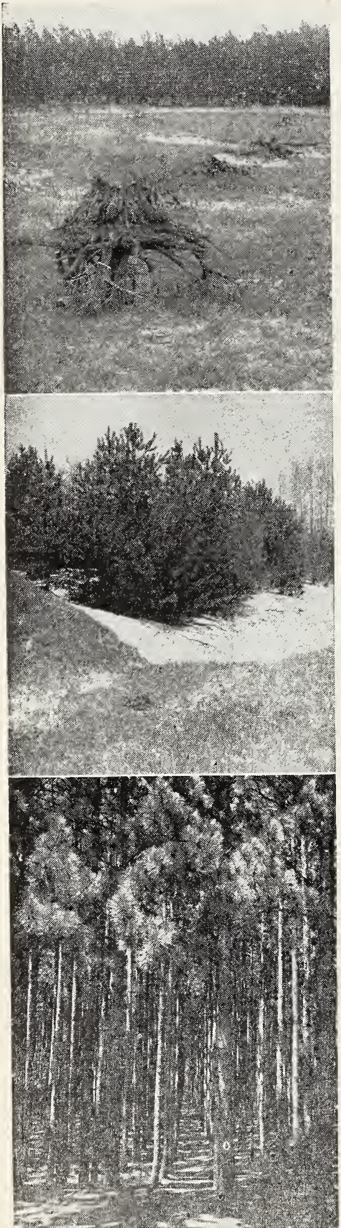


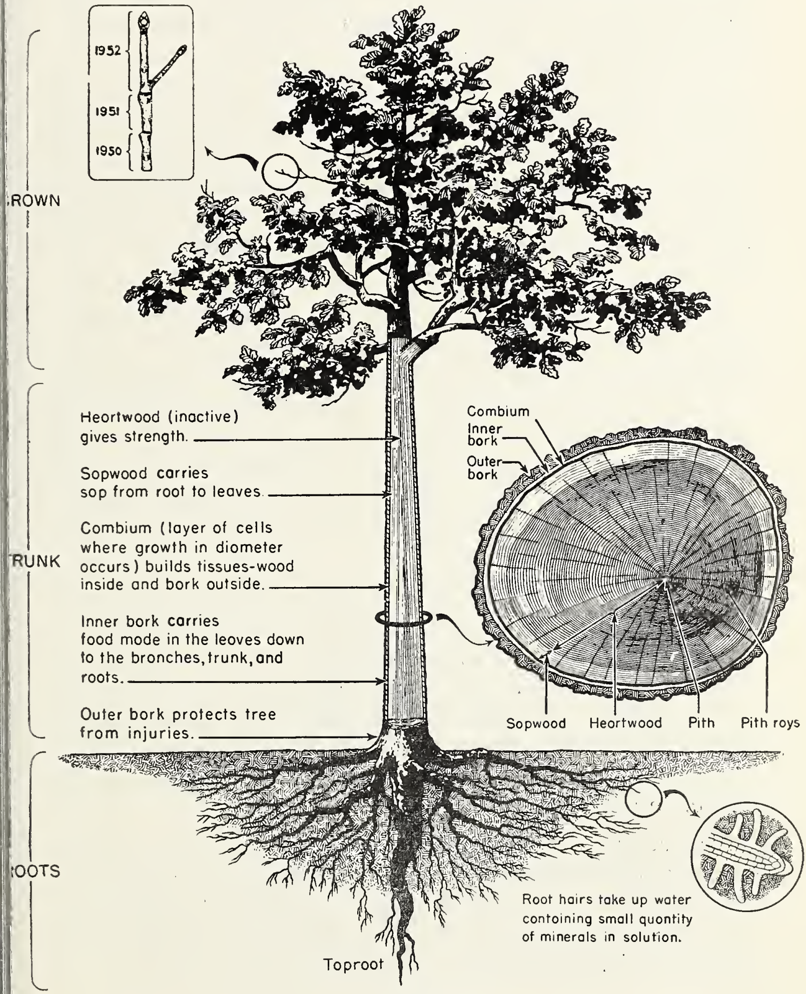
Fig. 17-1. Planting Trees Changes Waste Land to Productive Land.

Top: When the trees were removed, the wind was free to blow this sandy soil away from the roots of the stumps. *Centre:* Young evergreens have grown enough to hold the sand in place. *Lower:* A new forest of red pine where sand once blew.

HOW A TREE GROWS

Trees increase each year in height and spread of branches by adding on a new growth of twigs

Light and heat are required by the leaves in the preparation of food obtained from the air and soil. The leaves give off moisture by transpiration.



Heartwood (inactive) gives strength.

Sapwood carries sap from root to leaves.

Cambium (layer of cells where growth in diameter occurs) builds tissues-wood inside and bark outside.

Inner bark carries food made in the leaves down to the branches, trunk, and roots.

Outer bark protects tree from injuries.

Root hairs take up water containing small quantity of minerals in solution.

Fig. 17-2.

FOREST SERVICE
U S
DEPARTMENT OF AGRICULTURE

trunk and branches, and leaves. The roots hold the tree in place, absorb moisture and other plant foods from the soil, and serve as a storehouse for food in winter. The trunk and branches hold the leaves out to sunlight and carry raw foods to them. They also carry manufactured plant foods from the leaves to all parts of the tree.

The leaves are the tree's food factories: they take carbon dioxide from the air and combine it with water and minerals from the soil to make sugar and starch. To do this, they must have chlorophyll and be exposed to sunlight. The plant foods made in the leaves are either used for growth or stored for future use. Leaves give off surplus water and oxygen as waste products.

A tree grows in size of trunk, in height, in spread of branches, and in length and size of roots. Branches and roots lengthen as new growth takes place near their ends. The trunk, branches, and roots grow bigger around by producing a new layer of wood each year just inside the bark. The whole root system keeps growing year by year, always filling about as much space in the soil as the *crown* (the trunk and all the branches) fills in the air. Now study fig. 17-2 and continue to do so while you read.

Part of the wood of the tree is dead, and part of it is alive. The wood towards the centre, called *heartwood,* is dead; its main purpose is to give strength to the trunk. It may rot away, and the tree, quite hollow, can keep on growing. The wood between the heartwood and the bark is alive. It is called *sapwood* because it carries the tree's sap (water and dissolved raw foods) from the roots to the leaves. Sapwood is usually lighter in colour than heartwood.

Between the sapwood and the bark is a very thin, soft layer, known as the *cambium* layer. It is here that all new growth of wood and bark begins. Each year the cambium layer produces a new layer of sapwood on its inner side, and a very thin layer of bark on its outer side.

Have you noticed the rings around the end of a log or piece of wood? The drawing here shows them. These are rings of growth, each indicating a year's growth. Every year a new ring of sapwood is formed just inside the cambium.

The bark is the tree's coat of armour, protecting it from injury and from attacks by insects and plant diseases. As bark is made up largely of cork, it keeps the tree from losing water. The inner bark also carries plant foods from the leaves to all parts of the tree.

Like all other living things, a tree must breathe. This it does through little pores in the leaves, twigs, branches, roots, and trunk. When the soil around a tree remains covered with water for a long period of time, as in a swamp, the little pores in the roots fail to get air, and the tree dies of suffocation.

In autumn, trees prepare for both winter and spring. Many trees get ready for winter conditions by shedding their leaves. All trees prepare for winter by producing a protective covering over the tender growing ends of their stems. These coverings are a part of the buds. Buds, however, are chiefly a preparation for spring. They contain a tender growing point, tightly packed young leaves, and, sometimes, little flowers all ready to open in spring. From these buds, new leaves, twigs, and, perhaps, flowers grow in spring. Study fig. 3-3 again.

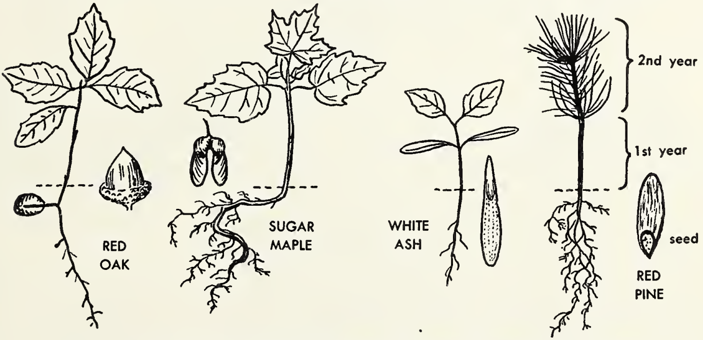


FIG. 17-3. SEEDS AND SEEDLINGS OF SOME COMMON TREES.

A tree cannot make food in spring before it has leaves. However, it must use food to nourish its opening buds. This food is always stored the previous fall in the roots, trunk, and branches. In spring it is carried to the leaves as a part of the sap. In maples this sap contains sugar, making it sweet.

Trees are reproduced by means of seeds (fig. 17-3). Like other seeds, those of all trees are formed from flowers, although these flowers may be very inconspicuous. Therefore, trees are flowering plants.

I wonder if they like it—being trees?
I suppose they do . . .
It must feel good to have the ground so flat,
And feel yourself stand right straight up like that—
So stiff in the middle—and then branch at ease,
Big boughs that arch, small ones that bend and blow,
And all those fringy leaves that flutter so.
You'd think they'd break off at the lower end
When the wind fills them, and their great heads bend.
But then you think of all the roots they drop,
As much at bottom as there is on top,—
A double tree, widespread in earth and air
Like a reflection in the water there.

I guess they like to stand still in the sun
And just breathe out and in, and feel the cool sap run,
And like to feel the rain run through their hair
And slide down to the roots and settle there.

Charlotte Perkins Stetson

SELECTING THE KINDS OF TREES TO PLANT. Before deciding to plant a particular variety of tree, we should learn what it needs with respect to soil, moisture, and light or shade.

On very dry, sandy soils, red pine and jack pine grow well. Sandy loams and well-drained loams are suitable for white pine and white spruce. Heavier soils, such as clay loam, will grow white spruce, Norway spruce, and sugar maple. White cedar and red or soft maple will thrive in very moist or swampy places. Willows grow best along streams. There they keep the soil from being washed away, and also give shade for fish.

THE WORK OF FOREST STATIONS. For many years the Forestry Branch of the Ontario Department of Lands and Forests has been helping to reforest large areas in Ontario that should be growing trees, but are not. To demonstrate the values and the methods of reforesting waste lands, and to provide the necessary trees, the Forestry Branch has established forest nursery stations in the counties of Norfolk (at St.

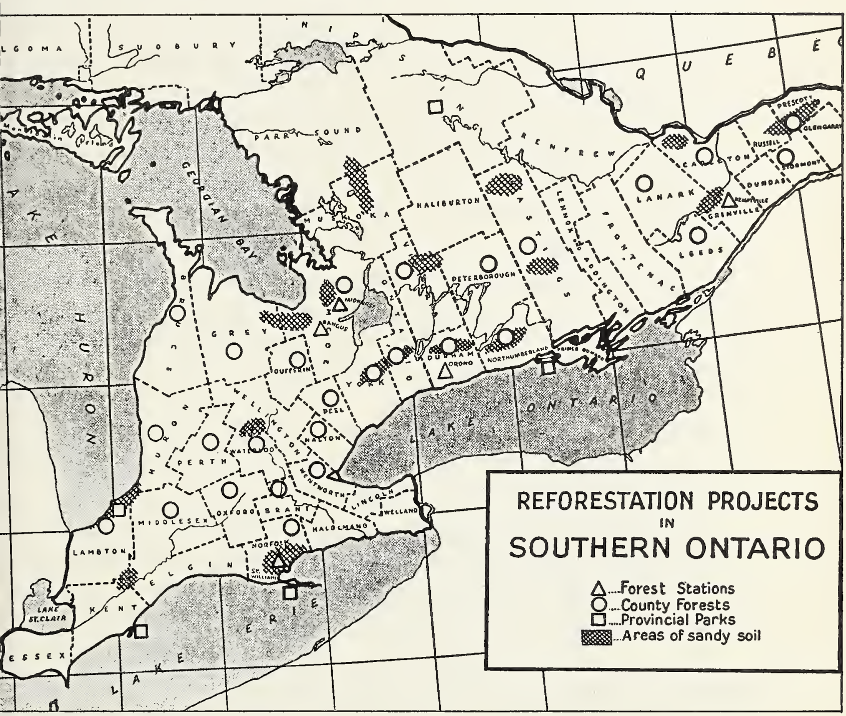


FIG. 17-4.

Williams), Simcoe (at Midhurst), and Durham (at Orono), and along the Rideau River (at Kemptville). It has also set up a forest seed station in Simcoe County (at Angus). Nearly 7,000 acres of land, most of it quite sandy, are being used in this way. See fig. 17-4.

In these forest nursery stations millions of seedling trees are grown to be distributed and planted wherever they are needed. Cones of evergreen trees are collected in autumn and stored in dry places until they open and set their seeds free. In spring the seeds are sown in carefully prepared seedbeds of sandy loam. The soil is covered with sacking and kept moist until the seeds germinate. The young plants are kept shaded, watered, weeded, and protected from birds and other animals. After growing in the seed beds for two years, the seedlings are transplanted into nursery plots for one or two more years.

When they are from 10 to 18 inches high, the seedling trees are distributed for planting where they are to grow permanently. They are more likely to get a good start when they are transplanted so young and so small. These seedling trees are supplied free to farmers and to schools.

TREES FOR SCHOOLS. By planting trees we can improve the appearance of our school grounds and, at the same time, learn how to plant and care for trees.

Single trees may be planted to give welcome shade several years later. These should be planted inside the boundary fence, not under power or telephone lines, and 25 to 30 feet apart so that they will not be too crowded when mature.

An attractive windbreak may be made by planting one or two rows of spruce, cedar, or other evergreen trees along one or more sides of the yard. To provide a good seed bed for the young trees, an area eight to ten feet wide should be thoroughly cultivated. Trees planted in a single row need to be four to eight feet apart; if in two rows, the trees should be six to ten feet apart in each row, and should alternate with the trees in the second row. The rows should be four to eight feet apart. All of these distances depend upon the variety of evergreen tree used.

A demonstration forestry plot may be planted in the school ground. This will show farmers and others who own waste land how it may be made productive again by growing trees. Unless the grounds are large, it may be necessary to secure nearby land for this purpose. Several schools in one township or in one community may combine to plan and plant such a demonstration plot.

PLANTING AND CARING FOR TREES. The best time to plant trees is in early spring, when they are at rest. The trees to be transplanted must be given good care both before, during, and after planting. Until planted, their roots should be kept moist in damp soil or moss, or in pails of water. The hole for a tree should be dug deeper and wider than its spread roots, and some good topsoil placed in the bottom of the

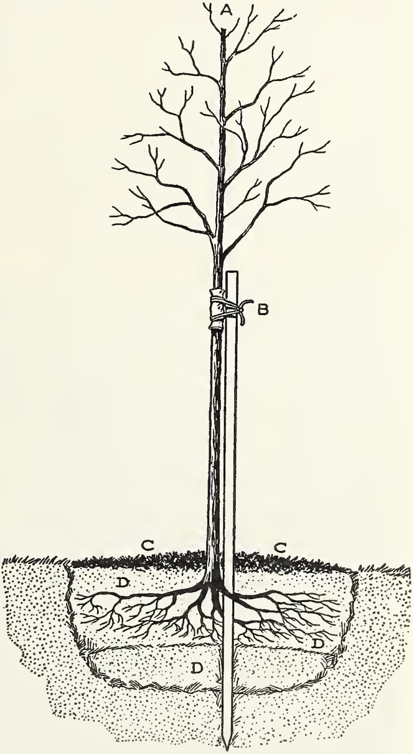


FIG. 17-5.

THE PROPER WAY TO PLANT A TREE. A, a few branches trimmed out from the top; B, the tree fastened to a stake, with canvas to protect the bark; C, a mulch of manure or decayed vegetation; D, good surface soil beneath and around the well-spread roots. Notice that the hole was dug deep enough and wide enough to accommodate all roots in a natural position.

hole. The roots should be spread apart in a natural position in the hole. Moving a tree gently up and down while filling around its roots with soil will help to make sure that there are no air pockets around the roots. After the soil has been pressed firmly around the roots, the depression should be filled with water, then with loose soil when all the water has soaked away. Study fig. 17-5 to review these steps.

The Ontario Department of Lands and Forests, Parliament Buildings, Toronto, supplies trees for Ontario schools free of charge. These should be applied for in late winter or the autumn before next spring planting, because of the great demand. Larger trees may be obtained from local woods, but must be transplanted with extreme care. Commercial nurseries also have desirable trees for sale.

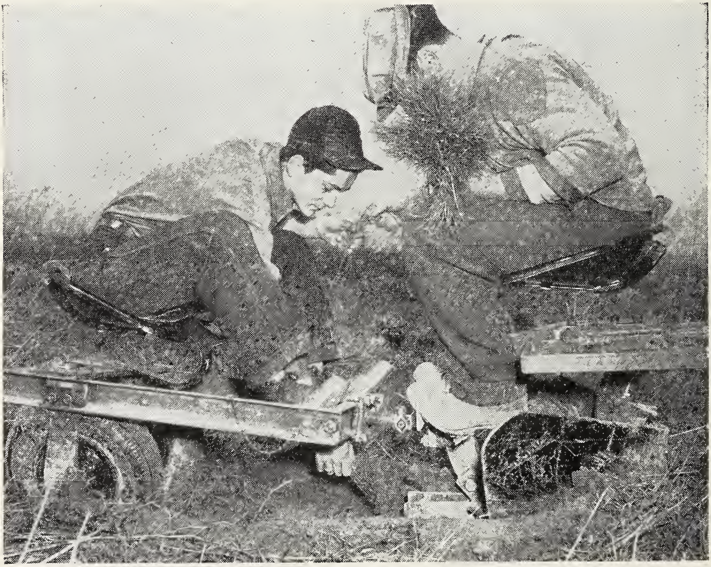


Fig. 17-6. Planting Young Evergreens by Machinery.
As this tractor-drawn tree-planting machine makes the trench, the men place the seedling trees where the soil will be pressed against their roots when the machine moves forwards.

After trees are planted, they require good care if they are to grow well. Watering them will be necessary unless rains keep the soil moist. Weeds must not be allowed to grow among young trees, for they will shade them too much and use up some of the water and other plant foods in the soil. Frequent cultivation of the soil around young trees will help it to hold sufficient moisture and air for good growth. Of course, trees must be protected from fire, livestock, and accidental injury by pupils.

PLANTING NEW FORESTS. In 1947 a group of forestry specialists (The Ontario Royal Commission on Forestry) estimated that 2,500,000 acres of land in Southern Ontario should be reforested to make it produce worthwhile crops, and to conserve soil and water. Instead of having less than ten per cent of the land in forests (1941 census for Southern Ontario), we should have about 25%, as has been proved wise in European countries throughout the centuries.

Several counties and townships in Ontario have planted (and are still planting) municipal forests on land too hilly or too sandy for agricultural crops. More than 80,000 acres of municipal forests had been planted in Ontario before 1950. The largest areas of these new forests are in the counties of Prescott, Russell, Bruce, Simcoe, Peterborough, Victoria, Grey, Northumberland, and Durham. Fig. 17-4 shows the location of many new forests in Southern Ontario.

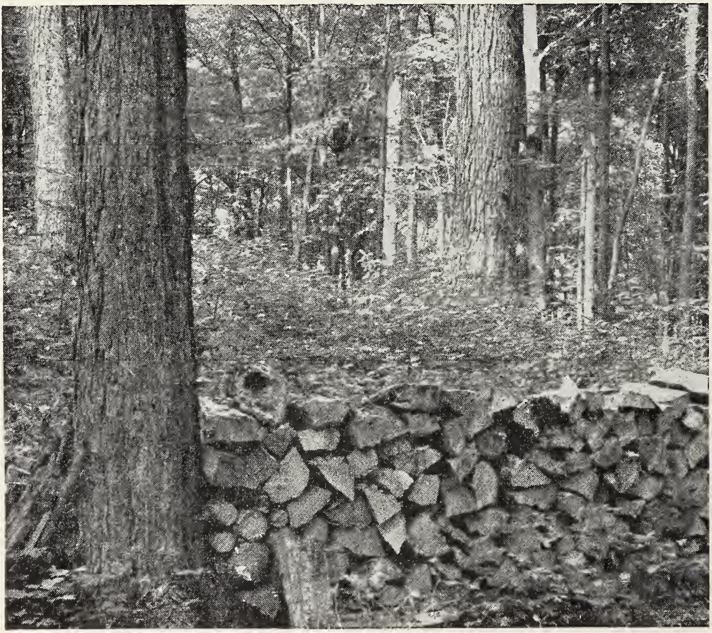
FARM WOODLOTS ARE VALUABLE. Farm woodlots are areas of wooded land on farms. Unfortunately, the total area of farm woodlots in Canada is now only about half of what it was fifty years ago. Most of these woodlots are given such little care that they produce much less lumber and wood than they should.

A well-managed woodlot on a farm is a constant and efficient servant of the farmer. It provides him with timber, lumber, fuel, and many other useful products. In five or more years the young evergreen trees in a woodlot become attractive

Christmas trees; in 20 to 30 years they provide useful poles and posts; in 80 years, a crop of timber and lumber. The water from rain and melted snow is conserved by a woodlot and becomes the ground water that nourishes the farmer's crops, fills his wells, and keeps his springs and brooks flowing freely. A woodlot also keeps the farmer's land from being eroded by water and wind. As a windbreak, it protects his crops and livestock. A woodlot bestows all these benefits, year after year, without having to be cultivated. See fig. 16-9.

LET'S HAVE MORE FARM WOODLOTS. Woodlots are so valuable that many farmers would make their farms worth more, both for themselves and for sale, if they were to grow

FIG. 17-7. A WELL-MANAGED WOODLOT.
Notice the presence of trees of all ages and the dense growth of young trees which give promise of a continued supply of fuel-wood as shown here.



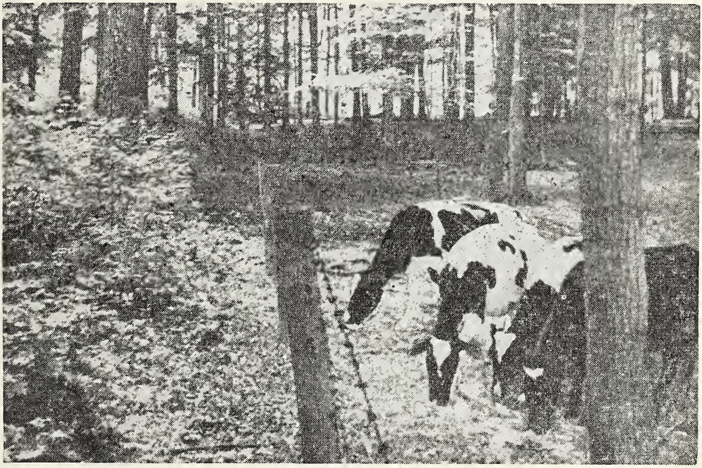
more trees. Trees should be planted on land that is being eroded, is too steep or too rough for cultivation, or is not sufficiently fertile for field crops.

Have you seen the name "Demonstration Woodlot" beside the highway? Four hundred of these, throughout Ontario, show people what a good woodlot is like, and how to make and manage one. See fig. 17-7.

An ideal woodlot should contain several varieties of trees, serving different purposes. Maple, birch, and beech will provide firewood; hard maple will produce an annual harvest of maple syrup and maple sugar; spruce and balsam may be cut while young for Christmas trees, or let grow older to provide posts, poles, and pulpwood; pine, oak, and all the trees mentioned above, when mature, will give valuable lumber.

A farm woodlot must be protected and well managed. All measures possible must be taken to prevent or control fires, insects, and tree diseases. Mature and defective trees must be removed to leave sufficient room for others to grow well. At

FIG. 17-8. A WOODLOT SHOULD NOT BE PASTURED.
Cattle destroy the young trees which would produce the future forest. Notice that there are no young trees where the cattle are grazing, but there is a wealth of young growth just across the fence from them.



all times care should be taken to avoid injuring growing trees and seedling trees when felling and logging.

Farm woodlots must not be pastured (fig. 17-8). Grazing animals eat seedlings and the leaves of small trees. The wood then lacks young trees to take the place of old ones. The hoofs of grazing animals injure tree roots and pack the ground so

Excursions to Woodlots

What To Observe	What To Do
Trees of different ages	Find a fresh stump. Count the rings of growth. Estimate the ages of other trees by their size.
Different varieties of trees	Use pictures of trees and of leaves to identify the trees.
Evidences of damage by fire, pasturing, and lack of replanting	Mark places where new trees should be starting growth.
Forest enemies such as insects and diseases	Collect insects and bracket fungi of different kinds. Identify them from pictures. Find out how they may be controlled.
Dead leaves, branches, and other litter on the forest floor	Find out how these affect the amount of moisture retained.
Young trees, small seedling trees, and other vegetation covering the ground.	Identify as many of these as you can. Think of their value in providing beauty and future trees.
Trees which, because of age, injury, disease, or insects, should be cut	Find out whether the owner is in the habit of removing such unproductive or unhealthy trees.

firmly that it prevents water from soaking in and nourishing the growing trees. Grazing animals change flourishing woodlots into weedy patches of trees.

A good farm woodlot, like any good forest, contains trees of all ages. In every part of it should be found mature trees, growing trees, saplings, and seedlings. To keep a woodlot this way, the old, mature trees should be selected each year for cutting. Of course, diseased trees, deformed or damaged ones, and those infested with insects should always be removed.

WINDBREAKS OR SHELTER BELTS. Nature did not plant trees in the grasslands of the Canadian West. They were not needed, for the prairie grasses kept the soil from drifting, prevented floods, and conserved moisture. The homesteaders soon found needs for trees: to protect themselves and their livestock by breaking the sweep of the prairie winds; to keep the dry, loose soil from being blown away after they had ploughed down the native grasses; and to protect the land in order that vegetables, fruits, and flowers might be grown successfully. To meet these needs, settlers in all three Prairie Provinces have planted belts of trees around their homes and between their fields. These protective belts of trees are called windbreaks or shelter belts. We shall speak of them as windbreaks. See figs. 17-9 and 17-10.

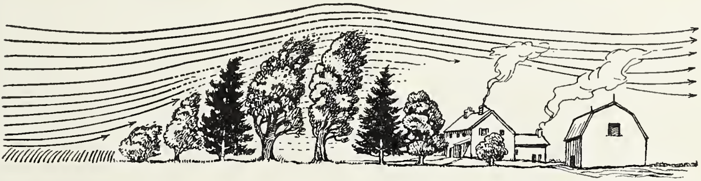


FIG. 17-9. A WINDBREAK PROTECTS FARM BUILDINGS.
Notice how the wind, forced upwards by the trees, blows well above the building.

Windbreaks usually consist of two or more rows of trees and shrubs. These serve best when they are arranged across the direction of the prevailing winds, or around farm buildings.

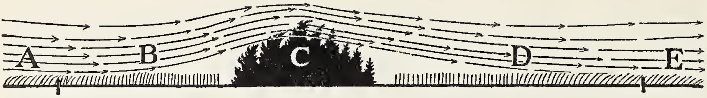


FIG. 17-10. A WINDBREAK PROTECTS CROPS FROM STRONG WINDS.

A, the wind blowing unhindered; B, the wind rising above the crops; C, the windbreak; D, the wind remaining high enough above the crops to avoid blowing them down or drying them out; E, the wind again down at crop level.

Evergreen trees, such as Norway spruce, red pine, and cedar, make windbreaks more effective. A well-planted windbreak will break the force of the wind and give some protection to soil and crops across an area even twenty times as wide as the highest trees (fig. 17-10). Windbreaks or shelter belts provide protection, homesites, and food for beneficial birds and useful wildlife.

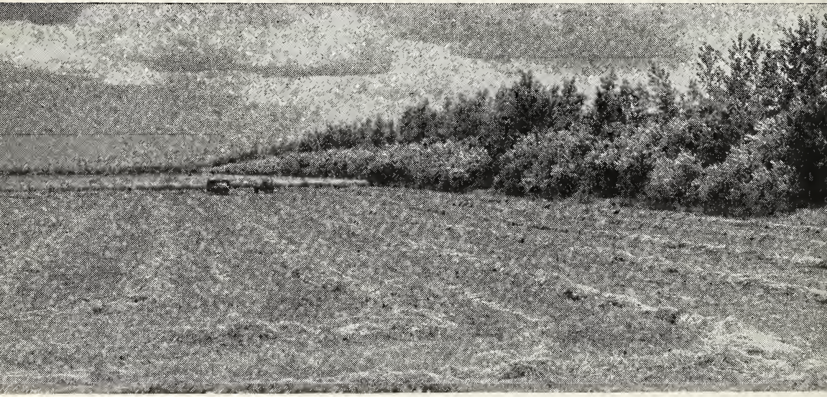


FIG. 17-11. AN EFFECTIVE WINDBREAK.

The good hay crop seen here has been improved by the protection given by the windbreak.

Some Learning Activities

1. Visit one or more of these: (a) nurseries, to see how tree seeds are collected and stored, and how tree seedlings are grown; (b) parks, to observe trees being planted; (c) the headquarters of a forest

warden, to study planting methods, firefighting equipment, and the rate of growth of trees.

2. Plant trees around the school, at home, or in a new woodlot—then see that they are well protected and cared for.

3. Plan a forestry week in your class. Display pictures, charts, posters, and maps to describe forests and woodlots. Arrange for appropriate motion pictures, talks, and discussions.

4. Write to the Forestry Branch of your provincial government, or to a forest station, to find out what kinds of trees are best suited to your part of Canada for windbreaks, for permanent woodlots, for dry or sandy areas, to prevent erosion on the banks of streams, and to shelter wildlife.

5. Collect cones of evergreen trees, leave them to dry, then shake out the seeds.

6. Grow some tree seedlings.

(a) Line a tumbler with two thicknesses of blotting paper. Place seeds of several kinds of evergreen trees between the paper lining and the glass, about two inches from the bottom. Half fill the centre of the tumbler with pebbles to hold the paper and the seeds in place. Keep an inch of water in the tumbler. Watch the seeds germinate.

(b) Plant some evergreen seeds and some acorns in shallow boxes of sandy soil. Keep the soil moist, and the boxes in a warm place. Observe the seeds germinate and the seedlings grow.

(c) Place winged seeds of maple or ash in moss, kept moist and in a warm place. Watch the young plants come up and grow.

Conservation Is Our Responsibility

We can conserve soil, water, and wildlife by planting forest trees:

(1) for crops: timber and lumber, pulpwood, poles and posts, firewood, and Christmas trees;
(2) to change idle land to productive land—on eroded slopes, in sandy areas, and on land too rough for cultivation;
(3) to reduce erosion by wind and water, and to conserve water;
(4) as windbreaks—to protect homes, fields, crops, livestock, and wildlife;
(5) to give shelter, home sites, and food for wildlife;
(6) to make our home surroundings more attractive.
(7) to provide recreational areas for ourselves.

Test Yourself

1. Make a list of forestry practices that will keep a forest or woodlot continuously producing a good crop of wood and wood products.

2. Tell how new forests can affect: floods in spring, the loss of water from melted snow and spring rains, erosion by water, erosion by wind, and stream flow in summer.

◆

16 mm. Sound Films

Seasonal Changes in Trees (SN-97) (colour)

Tomorrow's Timber (SS-123)

Return of the Trees (SA-16) (colour)

Farm Forestry (SA-15) (colour)
Ontario Visual Education Branch.

Trees Are a Crop (colour)

Windbreaks on the Prairies (colour)
National Film Board, Ottawa.

Seasonal Changes in Trees (black and white, also colour)
Associated Screen News Limited, Toronto.

Film Strips

Life of a Tree (with manual)
Ryerson Film Service, Toronto.

Making the Most of Your Woodlot
National Film Board, Ottawa.

◆

Think of This

Trees are a crop. While they grow, they serve us. When harvested, they continue to serve us in many ways.

As a crop, trees take a long time to grow. The trees we plant will be harvested by those who come after us. We should plant more trees, for in this way we preserve for others our Canadian birthright.

Canada's forests and fertile soil are basic foundations of her national wealth and of her future development. Not only do the forests create more than two million dollars worth of new wealth each day, they also make the fertile soil more productive by conserving water in the soil, preventing destructive floods and erosion, and making the climate more moderate and more favourable for the growth of crops. How important it is, therefore, that we protect and manage our forests so wisely that they will continue to ensure Canada's prosperity and growing importance as a great nation!

UNIT SEVEN

Our Living Comes from the Soil

18. *AGRICULTURE IS CANADA'S BASIC INDUSTRY*

Most people obtain their living from the soil. Because farms produce raw materials for many manufacturing industries and provide wide markets for manufactured goods, agriculture creates employment for millions of urban Canadians.

19. *SOIL, THE NATION'S BEST BANK ACCOUNT*

A few inches of soil is the source of food for nearly all the plants and animals upon which we depend. This chapter explains what soil is, how it is formed, and how it provides green plants with the water, minerals, and air they need to grow.

20. *SAVE THE SOIL*

Erosion is the soil's greatest enemy. Unless we conserve our fertile topsoil by using modern methods of cultivation to control erosion, it will soon produce insufficient food for the human race.

21. *MAKE THE SOIL MORE PRODUCTIVE*

Good soil is made less fertile by erosion, leaching, and growing crops. To enable soil to feed the earth's ever-increasing population, man, aided by nature and science, must conserve and increase soil fertility by such practices as rotating crops, growing grass, raising livestock, and applying fertilizers.

The photograph on the opposite page shows Brampton, its many greenhouses, and thousands of acres of Ontario's richest soil.

18

AGRICULTURE IS CANADA'S BASIC INDUSTRY

> Great is the sword and mighty is the pen;
> But greater far the labouring ploughman's blade;
> For on its oxen and its husbandmen
> An empire's strength is laid.
>
> *Rudyard Kipling*

THE PIONEER FARMERS in Canada depended largely upon themselves and their neighbours. They produced their own food and clothing, built their own houses and barns, and even made their own simple tools and farm implements. The early farm family, to be successful, had to work at carpentry, blacksmithing, weaving, candle making, meat curing, and many other industries now carried on by specialists. For large tasks, such as raising the framework of a barn, all members of the community gathered together as a "bee".

Our ways of living have changed. More than half the inhabitants of Canada now live in cities or towns. Some of these people are doctors, or engineers, or follow other professions; some are in business; others earn their living in manufacturing industries. At first thought, we might conclude that these people are no longer dependent upon agriculture for a living.

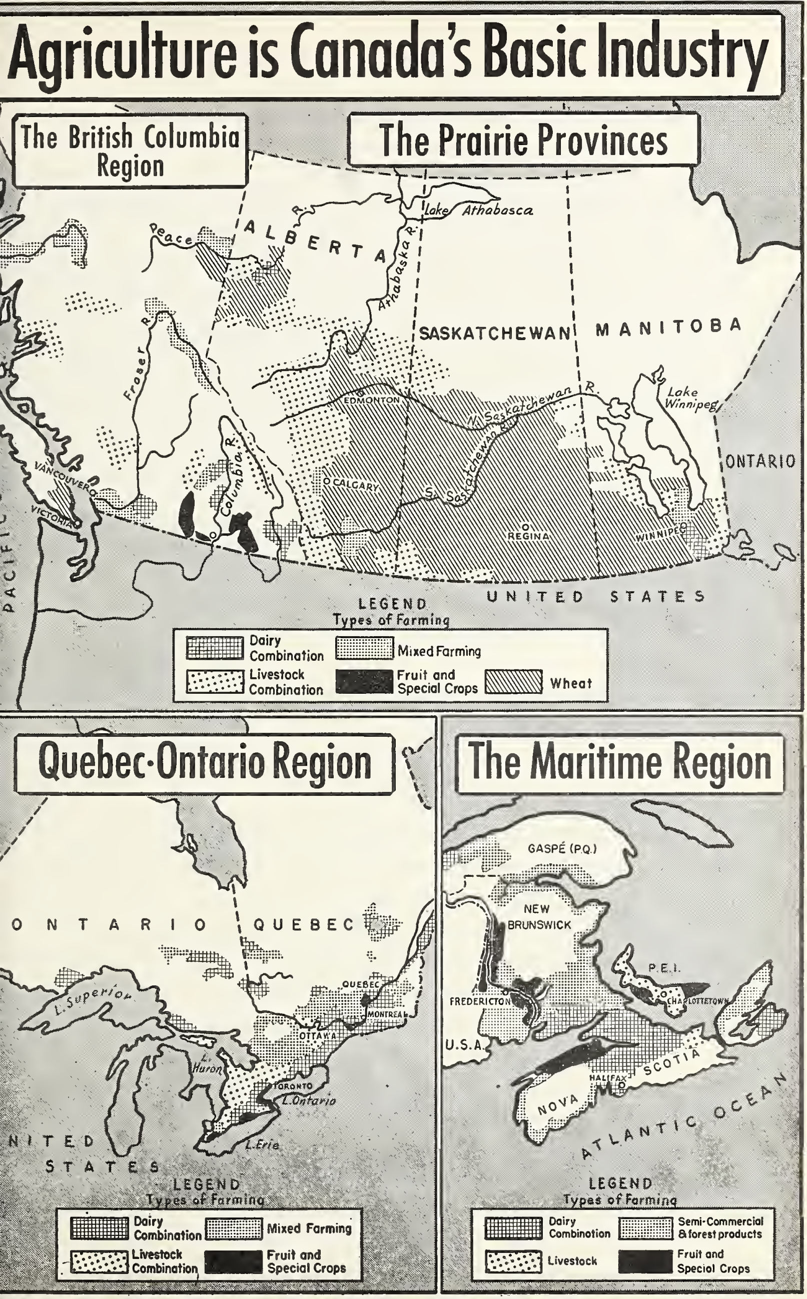


Fig. 18-1. Agriculture Is Important to All Canadians.

Is this true? Consider the sources of their food and of raw materials from which their clothing is made and their homes constructed. Many who do not cultivate a farm or a home garden earn their living, or a large part of it, by buying, selling, manufacturing, or transporting cereal products, fruits, vegetables, meats, woollen and leather goods, agricultural implements, and many other goods that are produced by the cultivation of the soil or are bought by farm people. Yes, agriculture remains the basic industry upon which all people, both urban and rural, depend for the necessities of life and much of the work by which they earn a living.

Farm Products Feed the Nation

The first requirement of a good farm is fertile soil. Good soil, supplied with the right minerals and enough water, and properly cultivated, makes green plants thrive and produce nourishing plant products. From these we obtain many of the carbohydrates and minerals in our diet. Farm animals begin where plants leave off. They change hay, grain, silage, grass, and root crops into animal products which supply a large proportion of both the proteins and the fats in our daily food. Truly, the farm feeds the nation.

FARMS PRODUCE MANY KINDS OF FOOD. Canada's agricultural resources are so varied that Canadian farms can produce most of the food we need. Between the Atlantic and the Pacific we find nearly every kind of soil and wide variations in temperature and in the amount of rainfall, making possible the successful growth of most kinds of agricultural plants. As a result, each area has developed its own characteristic kind of agriculture.

From the growing of grain we obtain bread, other cereal products, and food for livestock. The soil, climate, and surface features of the Prairie Provinces combine so well that they make the Canadian West one of the best grain-growing areas of the world, and wheat the most important Canadian crop entering into world trade.

FIG. 18-2. CANADIAN WHEAT FEEDS MILLIONS OF PEOPLE.
A field of wheat, like this, is as important to urban people as to rural people.

Livestock raising provides us with meat, lard, and many by-products. This branch of agriculture is especially important in Ontario and Quebec where most farms grow pasture for summer grazing and hay and grain for winter feeding. Cattle and sheep ranching are adapted to land too rough or hilly for cultivation, or too dry, as in the extreme southern parts of Alberta and Saskatchewan, for successful grain growing.

Our supplies of milk, butter, and cheese come largely from regions specializing in dairying. Dairy farms near cities supply most of our fresh milk. The milk from farms farther away is usually made into butter, cheese, or concentrated milk products which can be shipped greater distances.

Farmers in some regions engage in mixed farming. Instead of specializing in grain growing, stock raising, or dairying, these farmers engage in several branches of agriculture. Hay and grain are grown to feed livestock; livestock produce meat or dairy products; these serve as food for the family and as a source of income. The same farmers may engage in bee-keeping, poultry raising, and fruit growing.

Fig. 18-3. Apple Blossom Time in Nova Scotia.
Many farmers in Nova Scotia depend on the apple crop for a living.

Local conditions of soil and climate, or the needs of nearby urban people, may cause farmers to grow special crops. These three conditions often lead farmers near large cities to engage in market gardening, the growing of vegetables and small fruits chiefly. Because of favourable conditions of soil and climate, the Niagara Peninsula in Ontario, the Okanagan Valley in British Columbia, and the Annapolis Valley in Nova Scotia have developed into outstanding fruit-growing districts. Irrigation in Southern Alberta has led to the development of an important sugar-beet industry there.

FARM PRODUCTS ARE GRADED FOR MARKETING. Grading farm products to show their quality is an advantage both to the people who buy them and to those who sell them. When we buy eggs labelled "Grade A Large", we know that they are fresh, of good quality, and of large size, and we are content to pay more for them than for eggs with a lower grading. The farmer who sells them is rewarded by a higher price for producing better eggs and caring for them well.

Nearly all farm products sold for food are inspected and graded to show their quality. The "red" brand on beef indicates top quality. "Grade A" is stamped on only the best carcasses of pork. Poultry is similarly labelled for market. Baskets of fruits are stamped to show the grade, and all the fruit in a basket must be of the quality indicated. Potatoes and other vegetables are similarly graded for sale. Our Federal and Provincial Departments of Agriculture set the standards for grading all foods and enforce the regulations to protect both the producer and the consumer.

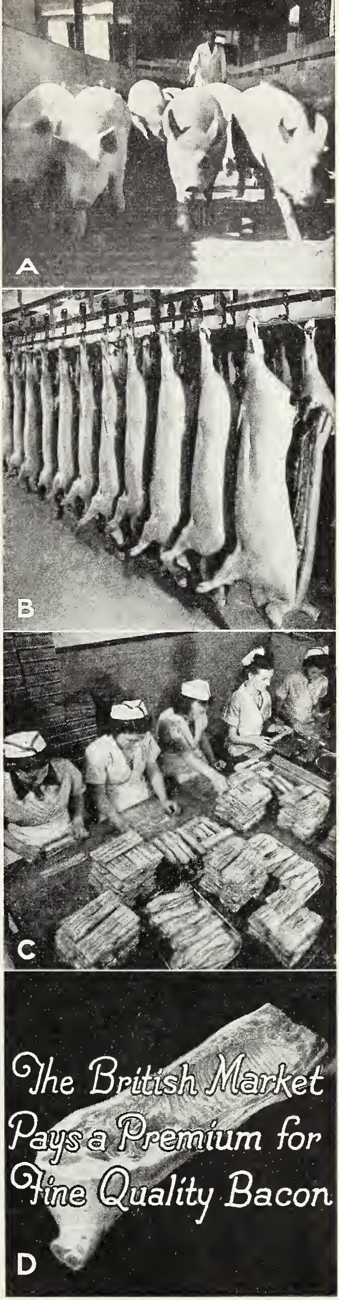


Fig. 18-4. Bacon from Farm to World Markets.

A, hogs on the way to be slaughtered; B, the dressed carcasses hanging in the cooling room; C, wrapping bacon; D, a Wiltshire side of bacon. Hogs and pork products are carefully graded for marketing.

Urban and Rural People Depend Upon Each Other

As new rural settlements developed in Canada, little villages grew up here and there. A post office was opened. A country store began to sell the farmer sugar, clothing, and hardware in exchange for butter and eggs. Usually a grist mill was built if there was a stream to give water power. A doctor opened an office. A blacksmith built his shop. One or more village churches were built where country and village people worshipped together. The village people settled there to serve the farm people; in return the farmers provided them with food and much of their income. The two groups were dependent upon each other. Neither could get along without the other.

The story is the same today, although we do not realize it as well. Large city department stores supply rural needs and give employment and income to urban people. Neither the packing house nor the livestock farmer could get along without the other.

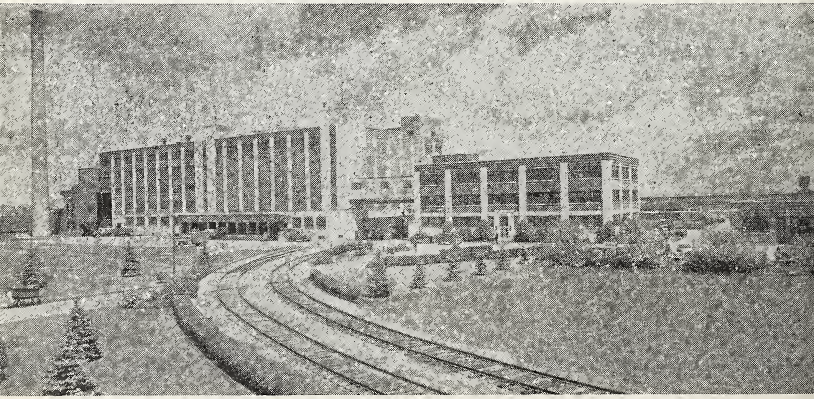


FIG. 18-5. A CANADIAN MEAT-PACKING PLANT.

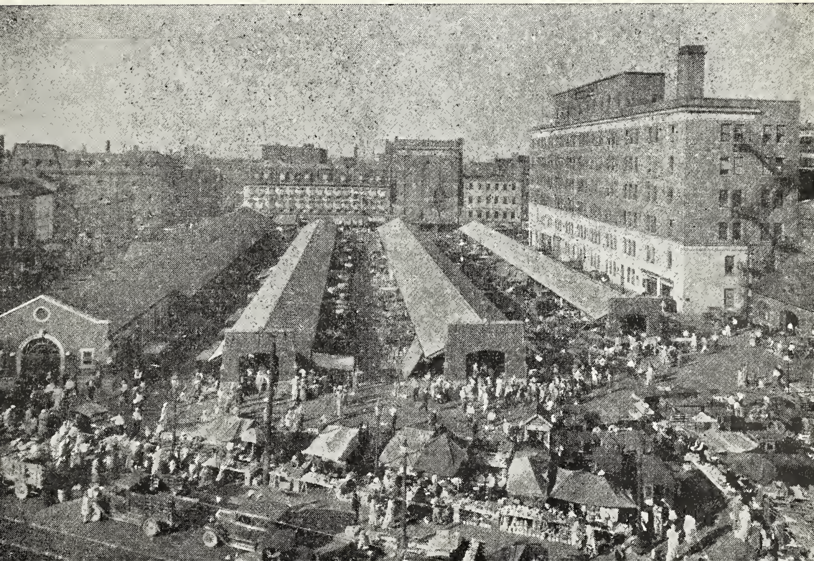
This packing plant at St. Boniface, Manitoba, helps farmers by providing a market for their livestock. It gives employment to factory workers, office workers, railway employees and people in many other walks of life.

HOW THE CITY DEPENDS UPON THE FARM. Agriculture contributes much to the people, the industries, and the other businesses in cities and towns. Let us find out how urban life depends upon farmers.

For Food. We have already become convinced that all people, whether in urban centres or in the country, depend upon agriculture for food. Even such processed foods as breakfast cereals, sugar, and ice cream come indirectly from the soil and the plants grown in it.

For Raw Materials for Industries. Many important industries depend upon the farm for raw materials to work with. Without wheat and other grains, there could be no milling industry; without livestock, no meat-packing industry; and without milk, no cheese factories, butter factories, or dairies. These industries not only provide us with everyday necessities, but give employment to many who work in factory and office.

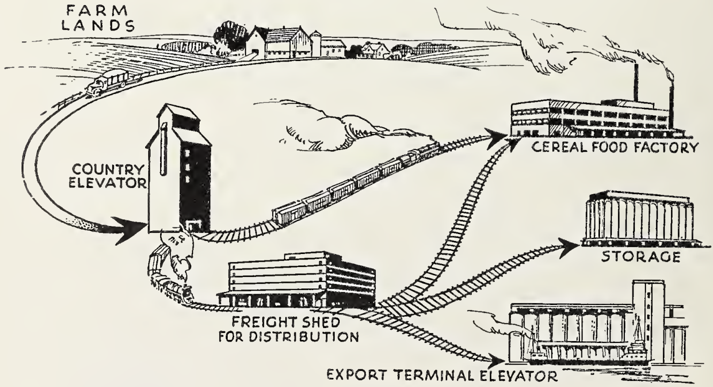
FIG. 18-6. WHERE RURAL AND URBAN PEOPLE MEET.
This market at Hamilton, Ontario, enables many city people to obtain meat, vegetables, and fruits produced on farms and in market gardens far and near.



For a Market for Goods Manufactured in the City. Many industries that give employment to city people sell their products entirely to people who are engaged in agriculture. Among these are the manufacturers of farm tractors and farm implements for cultivating the soil, sowing grain, planting potatoes, transplanting tobacco plants, and applying fertilizer to the land. All who work for these industries depend upon the farmer for their employment and their pay envelope.

For the Transportation and Storage of Farm Products. Farming is important to railway and truck companies. Much of their business consists of transporting manufactured goods to farms. To encourage farmers to settle on new land, railways were built into new and distant parts of the prairies that gave promise of growing good wheat. In this way railways obtained more farm business. When we think of the quantities of fruits transported from British Columbia to the Prairie Provinces, and of the grains and livestock carried from the Prairie Provinces to the East, it is easy to understand that nearly one-quarter of the freight carried by Canadian railways consists of farm products. Trucking companies also carry huge quantities

Fig. 18-7. Transporting and Storing Farm Products.



of farm products. Many thousands of people employed in transportation depend upon agriculture for a living.

The storage of meats, fruits, and other farm products gives employment to thousands of urban people. All those who work in the mammoth elevators at Fort William and Port Arthur, in those at other lake and ocean ports, and in the smaller ones throughout the Canadian West, depend upon agriculture for their living. So do those who are employed in storage plants for meats, dairy products, eggs, fruits, and vegetables.

HOW THE FARMER DEPENDS UPON OTHER PEOPLE. Farmers now depend upon others for many products and services that they used to supply for themselves. Not many years ago they took their own eggs to the store, delivered their own milk and livestock to the buyer, hatched their chickens on the farm, and mixed their own feed for the stock. Now these services are carried out largely by others who do not live on the farm. Milk and livestock are hauled by truckers;

FIG. 18-8. GRAIN PLOTS ON THE EXPERIMENTAL FARM AT CHARLOTTETOWN, P.E.I.
Scientists are constantly helping the farmers by developing new and better varieties of grain in plots like these.

baby chicks are bought from hatcheries; and much of the feed for livestock is bought from milling companies. Bread, cereals, meat, and butter, formerly prepared on the farm, are now bought from people who do not farm.

The farmer is dependent upon the urban worker for his modern farm machinery and household conveniences, the up-to-date implements and tools which have replaced the cruder ones made by his forefathers, and the many manufactured articles which make modern rural life similar in many ways to that in urban centres.

Rural and Urban Co-operation Helps To Build a Strong Nation

Better ways of living in country and city have developed side by side, and are dependent upon each other. Prosperity among farmers creates a market for many articles manufactured in urban centres. This, in turn, helps to make city industries more prosperous and to give city workers higher wages and better standards of living. At the same time, a prosperous urban centre can buy more farm products and pay higher prices for them. This increases farm income and makes it easier for farm people to enjoy modern conveniences and educational opportunities.

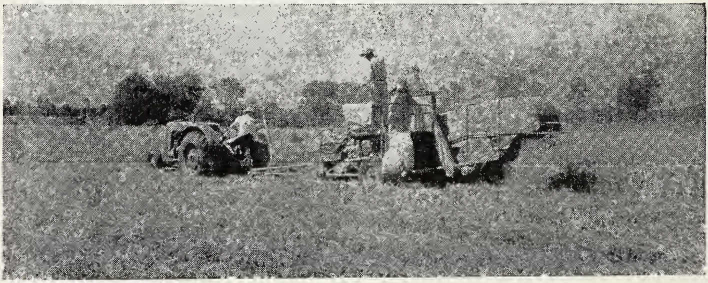


FIG. 18-9. A PROFITABLE FARM TEAM.
This combine harvester is saving time, labour, and money for the farmer. It made profits for the manufacturer and wages for the city worker. Modern machinery like this shows how farming and manufacturing can work as a team for the benefit of the farmer, the manufacturer, and the city dweller.

For Further Investigation

1. Name the branches of agriculture carried on in your community. After each, make a list of the farm products that are (1) used locally, (2) sold elsewhere.

2. Find out what farm products of your community are later manufactured into new products.

3. Write to the Department of Agriculture at Ottawa for the regulations concerning the grading of eggs, dairy products, meat, and poultry.

4. If you live in an urban community, make a list of all the things you use in your home that depend upon agriculture in some way; if you live on a farm, make a list of all the things in your home that depend upon the help of people who earn their living in an urban centre.

5. Make a list of the most important products of the soil under the headings: food, clothing, shelter.

For Class Discussion

1. How does the prosperity of farmers affect the prosperity of the nation as a whole? Discuss the question under these headings:
   (a) industries that manufacture articles used on farms;
   (b) industries that use farm products as raw materials;
   (c) industries that transport products sold by farmers, and goods bought by farmers;
   (d) the employment of men in mining and steel industries.

2. How does the efficiency of farming practices and the resulting prosperity of the farmers in a large area affect the welfare of such people as: doctors, lawyers, teachers, ministers, engineers, store keepers, farm machinery agents, service station owners, automobile salesmen?

◆

Read

Compton's Pictured Encyclopedia: "Farm Life" (many articles), Vol. 5, pp. 21-36, and "The Golden Grains That Give Us Our Daily Bread", Vol. 15, pp. 115-118.

16 mm. Sound Films

Story of Standards (grading) (colour)
National Film Board, Ottawa.

Food from the Land
United Kingdom Information Office, Ottawa.

Film Strips

Our Resources—Agriculture, Part 1
Our Resources—Agriculture, Part 2
Our Resources—Agriculture, Part 3 (post-war)
The Story of Wheat
National Film Board, Ottawa.

19

SOIL, THE NATION'S BEST BANK ACCOUNT

LIKE A GOOD BANK ACCOUNT, the soil is a storage place for wealth. In fact, it is the origin of most of the earth's riches. It provides us with our food, our clothing, and much of our shelter. Upon it depends our living, our health, our comfort, and our future.

FIG. 19-1. SOIL GIVES FOOD, CLOTHING, SHELTER, AND TIMBER.

Soil, with the help of water and air, enables green plants to grow. This makes possible all animal life. Thus soil provides most of the things we need for our daily living: wheat for our bread, vegetables for our health, trees for our shelter, fibres for our clothing, flowers for our enjoyment, livestock for our meat, wildlife for our pleasure.

A nation's wealth depends upon the abundance of its products for use and export. Therefore, fertile soil is the best bank account a nation can have.

Rocks Become Soil

The thin layer of soil that man has ploughed and cultivated since he settled on the land is the important part of the soil for most plants. Trees and other deep-rooted plants, however, take water and minerals from soil farther down. All the soil that is used to feed plants is so important to us that we should try to understand what it is, how it was formed, and the wisest ways of using it.

OF WHAT IS SOIL COMPOSED?

EXPERIMENT 19-1. Use water to separate the different kinds of materials in soil.

> Nearly fill a quart jar with water. Into this pour a cup of garden soil. Cover the jar, then shake the mixture vigorously. Let the jar stand, and watch the particles settle. What kind of particles settle first? Next? Last? Notice the size of the particles at the bottom, halfway up, and at the top of the settled layers. Compare your observations with those shown in fig. 19-2, A. How long does it take the cloudiness to disappear from the water? Make a drawing to show the results of your experiment.

The water sorts out the particles according to size. First, the larger particles, *gravel* and *coarse sand,* settle out; after these, the *medium sand,* then the *fine sand.* Taking still longer to settle are the finer particles, called *silt,* and the finest ones, called *clay.* Sand particles may be as large as the head of a pin, or much smaller. Clay particles are so fine that it takes more than 5,000 of them laid in a line to make an inch. For this reason, they float in the air as dust, or they remain in suspension in water for several hours before they settle and leave it clear. Particles of humus are so light that they remain floating or settle gradually with the top layers of clay.

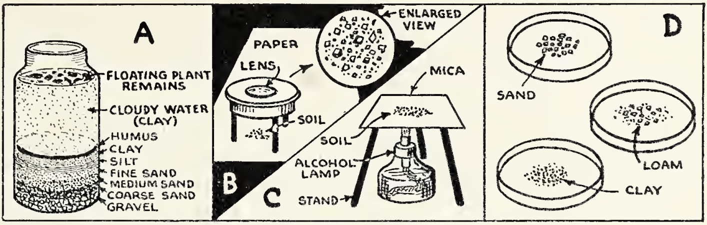


FIG. 19-2. FINDING THE COMPOSITION OF SOIL.

A, by shaking it with water; B, by examining it with a lens; C, by burning it; D, making a loam soil.

EXPERIMENT 19-2. What makes soil gritty?

(a) Rub some soil between your thumb and finger, or between a knife blade and a hard surface. Sand particles make soil gritty.

(b) Place a little of the soil on a white paper and examine it with a lens (fig. 19-2, B). Look for glossy rock particles, also dull bits of partially decayed vegetation. Look for different-sized and different-coloured grains of sand.

EXPERIMENT 19-3. Test some soil for decayed vegetation.

Heat some garden soil intensely on mica or on the top of a stove for about 20 minutes. Notice the peculiar odour and the reddish ash formed by the burning of the decayed vegetation, known as *organic matter*. Because forest floors are usually covered by a thick layer of decaying vegetation, forest fires often burn deep and leave a layer of reddish ash.

Soil is a mixture of mineral matter, decaying remains of plants and animals (organic matter), water, air, and living things. Most of the soil is mineral matter in the form of fine particles of sand, silt, and clay. Mixed with these is the organic matter, some of which has decayed enough to be called humus. Filling the spaces between these particles is air and usually some moisture. All through the mixture are the living roots of plants, tiny bacteria and moulds, and a variety of small animals. Growing plants take minerals from the rock particles, and nitrogen and other foods from the humus.

HOW IS SOIL FORMED? At one time there was no soil; the surface of the earth was all rock. Throughout millions of years nature has worked on this rock and gradually changed its upper layers to fertile soil.

Changes in Temperature Break Rocks. Two experiments will help to explain how this happens.

EXPERIMENT 19-4. How do changes in temperature cause rocks to break?

Heat a piece of glass. Drop some cold water on one side of it. Why does the glass break?

When the glass was heated, it expanded. The cold water cooled one side of it and caused this to contract more than the other side. As a result, the glass broke.

A sudden shower of cool rain, likewise, causes sun-heated rocks to break. Frequently farmers break large rocks in their fields by building bonfires on them, then throwing cold water over them.

EXPERIMENT 19-5. How does the freezing of water break rocks?

Fill a small-necked bottle with water, close it with a stopper, then place it where the water will freeze. What happens? The bottle broke because water expands while freezing.

Large rocks frequently have crevices in which water may collect. Many rocks are porous enough to contain small amounts of water. When the water freezes in either the crevices or the pores, it expands, frequently with enough pressure to break off pieces of rock.

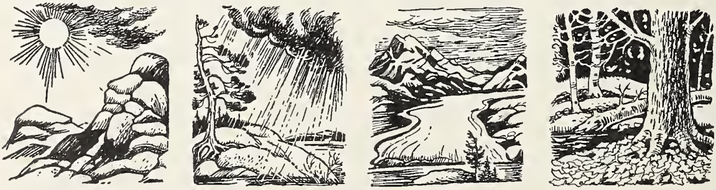


FIG. 19-3. HOW SOIL IS FORMED.

The sun and changes in temperature cause rocks to break; rain and water from other sources wear and dissolve rocks; a glacier grinds rocks to soil; decaying vegetation adds organic matter to the soil.

When these things happen over and over again, rocks become broken into smaller and smaller pieces until they become soil.

Water Wears and Dissolves Rocks To Form Soil. Water running over rocks, particularly if it carries sand or pebbles, wears the rocks to soil as sandpaper wears wood to dust. Rain beating against rocks slowly wears them away. When carbon dioxide from the air is dissolved in rain water, it forms an acid which dissolves particles from some rocks. We can see how this happens by putting a drop of vinegar on a piece of chalk, marble, or limestone.

Air Weathers Rocks To Form Soil. When air, as wind, drives particles against rocky surfaces, some of the rock is worn away. You know that the oxygen in air rusts tin cans until they break up. In the same manner, it rusts bits of iron in rocks and causes them to crumble and form soil. These are only two examples of *weathering,* the wearing away or the breaking down of substances by air or water, heat or cold — anything included in the term *weather.*

Glaciers Grind Rocks to Soil. The massive layers of ice, called glaciers, and formed over long periods of time, carry stones and gravel in their bases. As such masses of ice and stones move slowly along, they grind some of the rock within and beneath them to powder, and carry it along with them. When the ice melts, it leaves this newly formed soil, mixed with stones, in ridges or layers. Much of the soil of Central Canada was formed and deposited in this way.

Plants Help Rocks To Form Soil. The first plants to grow on rocks are those flat, grey patches that we call lichens, and the thicker mats of moss. As these grow, they dissolve some material from the rocks and use this for food. When they die and decay, their bodies form some humus. This humus becomes mixed with rock particles to form soil in which other plants may grow.

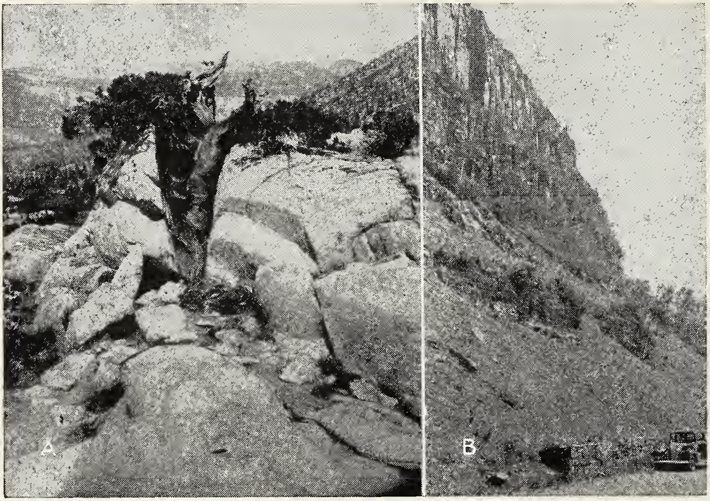


FIG. 19-4. ROCKS BECOMING SOIL.
A, rocks split by the roots of an old tree; B, rock broken from the face of a cliff and weathered into soil sufficiently that some trees have started to grow in it.

Many plants, while living, shed leaves, branches, and other waste products. These gradually decay and form leaf mould or humus. The plants themselves become humus when they die. Gradually, as more rocks become ground up and more plant remains become mixed with this ground rock, the soil becomes deeper. To make an inch of good soil takes nature several hundred years.

Animals Assist in the Making of Soil. Earthworms and other animals that live in the ground or in decaying

FIG. 19-5. MOSS HELPS NEW PLANTS TO GET STARTED.
As moss plants live and die on rock, they help to form a little soil.

vegetation help to change plant life to humus and to mix this with the soil. Their burrows make it possible for air and water to enter the soil freely and weather rock particles.

PUPIL INVESTIGATIONS. How do animals help soil?

> Collect two quarts of soil from: (1) just under the dead leaves in a forest; (2) under the grass in a pasture; (3) the subsoil in an eroded field. Spread each on a paper and examine it for worms, grubs, snails, insects, spiders, and any other animals. Which soil contains the most animal life? Which soil was loosest when dug up? Small animals help to keep soil loose, making it easier for water and air to enter it.

COMMON KINDS OF SOIL. Soils are classified into different kinds according to the sizes of their particles. You will remember from experiment 19-1 that garden soil contains sand, silt, and clay particles. These were described on page 318.

Soil that is made up chiefly of sand particles along with a small proportion of silt and clay particles is called *sandy soil.* Sandy soil is open, airy, and easily cultivated, and lets water enter and pass through it with ease. Unfortunately, sandy soil does not usually contain enough plant food, humus, or water to nourish crops well.

If soil contains more silt and clay, but is still more than half sand particles, we call it *sandy loam.* The large proportion of sand in this kind of soil makes it loose, airy, and easily cultivated; the extra silt and clay make it fertile enough to grow garden crops satisfactorily.

When soil is about half sand and half silt and clay particles, is it called *loam.* This soil is likely to contain more plant food, humus, and moisture than either sand or sandy loam. Loam is quite easily cultivated, does not become sticky when wet, or hard when dry, and is therefore good for most crops.

When there is a little more silt and clay than there is sand, the soil is called *clay loam.* This is the best soil for most kinds of crops. Because it admits water freely and holds it better than other loams, the plants growing in it can withstand periods of drought. Because it stores more plant food, it needs less fertilizer. Clay loam is quite easily cultivated except in very wet weather or in long periods of drought.

Soil that contains a very large proportion of silt and clay, and only a small amount of sand, is called *clay* soil. This soil is usually rich in plant foods. However, it is so sticky when wet, and so hard when dry, that it is difficult to cultivate and, therefore, unsatisfactory for either general farming or market gardening.

Because sand and sandy loam are so easily cultivated, we call them *light* soils. Clay loam and clay are so difficult to work that we call them *heavy* soils.

Soils differ also in the amount of humus they contain. This is likely to be present in desirable quantities in loam and clay loam. Humus makes clay and clay loam easier to cultivate; it also increases the amount of plant food and moisture held in any soil.

EXPERIMENT 19-6. Compare the effects of water on different kinds of soil. In three separate dishes place some clay soil, some sandy soil, and some loam. Stir water into each until it is muddy. Leave each to dry. Which dries hardest? Which cracks most when dry? Which would be most easily cultivated?

EXPERIMENT 19-7. Compare the growth of plants in different kinds of soil. Fill different flower pots with sandy soil, sandy loam, loam, clay loam, and clay soil. Plant two or three different kinds of seeds in each. Keep all pots under the same conditions of moisture and warmth. In which pot do the seeds germinate first? In which do they grow best? Try to explain your observations.

Things To Do

1. Each pupil bring from home a sample of soil, then repeat experiment 19-1 to discover the proportions of sand and of clay in it.
2. Make a school display to illustrate the different kinds of soil: sandy soil, sandy loam, loam, clay loam, and clay soil.

A Class Review Exercise

Make a blackboard table to compare the five kinds of soil with respect to their composition, water-holding capacity, fertility, ease of cultivation, and the kinds of crops for which they are best suited.

TOPSOIL AND SUBSOIL. The soil that nourishes our crops is usually found in two main layers, a few inches of topsoil, then the subsoil beneath this. The topsoil is both fertile and dark in colour because it contains so much decayed organic matter or humus. For the same reason, it produces most of the world's food. Scientists believe that it takes nature from 500 to 1,000 years to mix enough decayed vegetation with particles of rock to produce one inch of good topsoil.

The subsoil, just beneath the topsoil, contains less plant food, is less productive, and appears lighter in colour, all because it contains so little decayed vegetation. For the same reason, it is less porous, absorbs less moisture, and is more difficult to cultivate. A side view of the soil, as we would see it in a road cut or in a deep ditch, is called a *soil profile*. Such a soil profile shows the nature and the amount of topsoil and subsoil, and helps us to judge how productive a soil is.

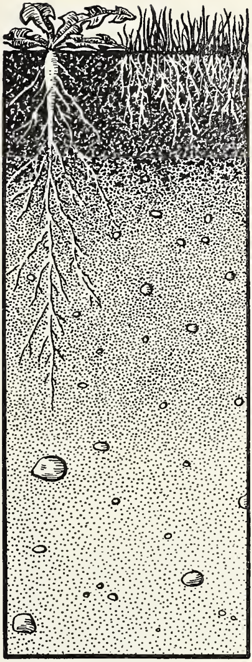


FIG. 19-6. A SOIL PROFILE.

Notice that the roots of plants extend down through the rich, dark topsoil into the lighter-coloured subsoil.

Some Investigations

1. Collect samples of topsoil taken from a cultivated field, a wood, and a fence corner where grass has grown many years, and of subsoil from an excavation. Compare them in colour, in the amount of humus they contain, and in their ability to grow plants.

2. Examine a roadside cut or a deep ditch; then draw and label a soil profile of it.

Soil Nourishes Green Plants

The soil feeds the plants that feed man. Although the seed from which a plant grows gives it a good start in life, the young plant must soon find and make its own food. The soil helps it to do this.

SOIL AND PLANT FOODS. The plant foods supplied by soil are water, minerals, and nitrogen. Water is a food for plants; it also dissolves and carries into the plants the other raw foods. Nitrogen is supplied by decaying plant remains, by some other chemicals in the soil, and sometimes by bacteria which take it from air in the soil. Among the minerals supplied to plants by soil are two very important ones, potassium and phosphorous. In chapter 21 we will learn how nitrogen and minerals serve plants, and how we may add them to the soil in fertilizers when necessary.

The ability of a soil to produce good crops depends not only upon the kinds and amounts of plant foods in it, but also

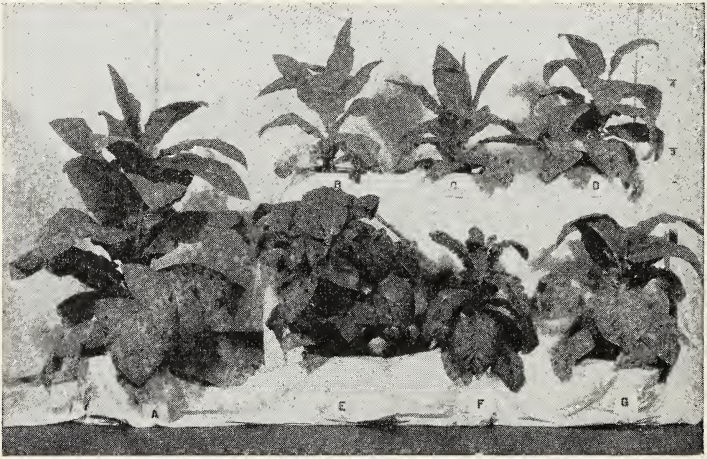


FIG. 19-7. PLANTS NEED MANY KINDS OF FOODS.
These plants are growing in water containing some of the chemicals needed by plants. A, all necessary chemicals present; B, without nitrogen; C, without phosphorous; D, without potassium; E, without boron; F, without calcium; G, without magnesium.

upon the water, air, heat, and bacteria it contains. The farmer can do much to control these last four conditions by his methods of farming.

SOIL AND WATER. All soils contain water. Dry soils contain a little water; garden soils in good condition for cultivation contain enough for plants to grow well; wet soils may contain so much that it excludes the air needed by roots of plants.

Most of the water in the soil comes to it as rain or snow. The part that stays in the top layer of soil is immediately useful to plants.

How Plants Use Water in Soil. Water is, in itself, a plant food. Much of it helps plants by dissolving other plant foods from the soil and carrying them into the roots and up to the leaves.

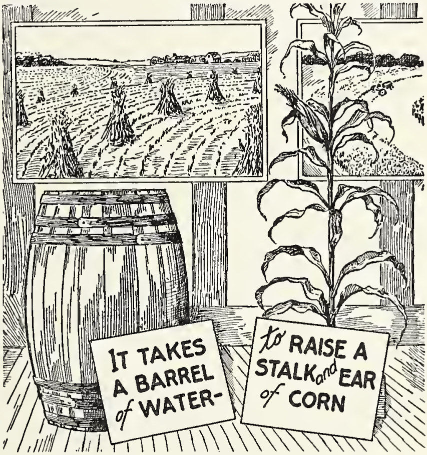

IT TAKES A BARREL of WATER-
to RAISE A STALK and EAR of CORN

FIG. 19-8.

Good Soils Absorb Water Well. Only the water that a soil absorbs is useful to plants growing in it. That which runs off does harm by carrying away good soil, by dissolving and taking minerals with it, and by causing floods. Soils that are porous, those that contain much humus, and those that are kept well cultivated, all absorb moisture well.

In chapter 20 we shall learn how farmers try to make soils take in more water instead of letting it run off.

Good Soils Retain Water Well. The value of a farm is determined largely by the ability of its soil to retain moisture.

EXPERIMENT 19-8. What kind of soil retains water best?

Punch several holes in the bottom of each of four equal-sized vegetable cans. Put into the four, respectively, equal quantities of coarse sand, sandy loam, clay loam, and clay loam containing much humus—all dry. Rest each on a tumbler. See fig. 19-9, A. Pour equal amounts of water onto the four kinds of soil until water drains from each. Compare the amounts of water in the tumblers when no more runs through the soils. Which kind of soil retains the most water?

Clay soil and clay loam retain more moisture than sandy soil or sandy loam. Frequently the latter two kinds of soil do not retain enough moisture in dry summers for crops on them to mature. Such soils can hold more moisture if they contain much humus.

In dry weather, plants depend upon the moisture in the layers of soil below the roots.

EXPERIMENT 19-9. Does water rise through soil?

Let the soil of a potted plant become dry. Place the pot in a saucer of water. How does the amount of water in the saucer change? Where did it go? If there is enough water, it may rise to the top of the soil.

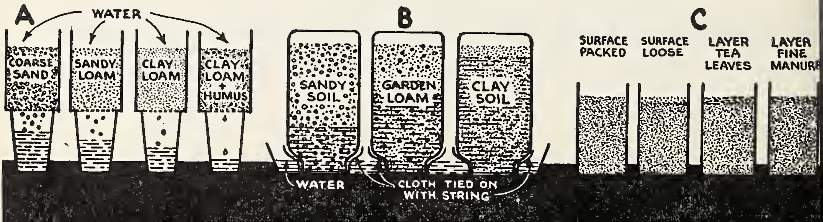
EXPERIMENT 19-10. In what kind of soil does water rise highest?

Obtain three sealers. Fill one with sandy soil, one with garden loam, and one with finely pulverized clay soil or clay loam. Tie a cloth over the mouth of each sealer. Invert all three sealers in a pan of water as in fig. 19-9, B. Watch the water rise in each.

Through which kind of soil does the water finally rise the highest? What kind of soil would be best on a farm in an area subject to periods of drought? Why?

FIG. 19-9. SOILS IN RELATION TO WATER.

A, finding the water holding capacity of different soils; B, finding out what kind of soil conducts moisture upwards through it most efficiently; C, showing that a mulch helps to retain moisture in the soil.



The finer the particles in soil, the more easily the water rises through it. For this reason, loam and clay loam are more efficient than sandy soil in carrying water upwards towards the surface, and better for plants in periods of drought.

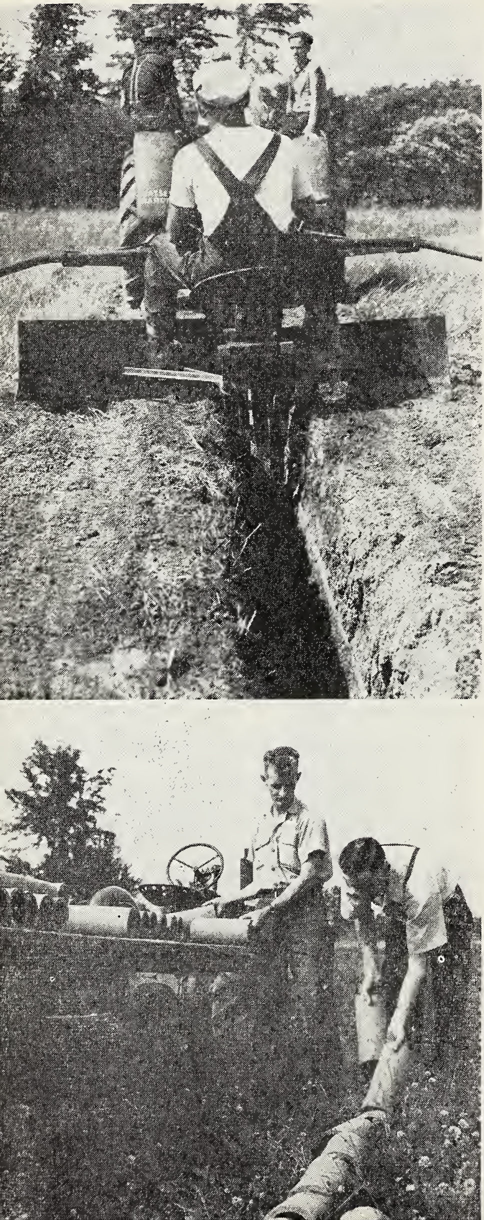
In dry weather the water in the soil must be prevented from evaporating into the air. Farmers and gardeners can do this by keeping soil covered with a *mulch* of loose material such as straw, manure, or crop refuse, or by keeping the surface of the soil well pulverized by cultivation. For the same reason, if we cover the soil of potted plants with a layer of tea leaves or fine particles of decaying vegetation, they will not need watering so often.

Water Must Be Added to Some Soils. Even when the farmer has taken many precautions to make the soil better able to absorb and retain moisture, it may still contain too little water to grow good crops. On farms of sandy soil, and in areas where there are long periods of drought or of very hot weather, crops will not mature unless water is supplied by irrigation. We will learn in chapter 21 how this may be done.

Water Must Be Drained from Some Soils. Too much water on or in the soil is as unfavourable as too little for plant growth. Water that stands on the surface or remains in the spaces between soil particles hinders cultivation. It also keeps air from reaching the roots of plants, causing them to turn yellow, stop growing, and perhaps die.

Excess water on the surface, or in the spaces between soil particles, should be removed by *drainage*. It may be drained away by open ditches or by underground tiles.

Open ditches should be dug in low-lying parts of a farm so that the surplus water will drain from the surrounding soil into them. Several ditches as small as plough furrows may lead to one larger one. The main ditch may lead to a creek, or merely to a pasture or other grass-covered place. All ditches must slope towards this outlet so that the water may flow freely to it.



Clay or concrete tiles drain farm fields more efficiently than ditches. Tiles are about a foot long and are three inches or more in diameter. They must be laid with care. A ditch is dug about 2½ feet deep, with an evenly sloping base. In this the tiles are fitted together closely, end to end. Then the ditch is filled with soil. Surplus water in the soil seeps into the tiles between their ends. The row of tiles must have a gradual slope so that the water can flow freely through them to the outlet. To keep them from being blocked, they must be laid far enough from trees to prevent roots from entering the joints, and

FIG. 19-10. DRAINING A FIELD IN EASTERN ONTARIO WITH TILES.

Top, a ditching machine digging the trench; bottom, delivering tile to be laid in the trench.

their outlets must be screened to keep out animals and refuse.

Open ditches have four disadvantages over tile drains: (1) they hinder the use of farm machinery; (2) they encourage weeds to grow, and these spread to crops; (3) they require re-digging frequently to remove sediment; and (4) they are a constant danger to livestock. Tile drains cost more to instal, but, if properly laid, they are permanent and drain the land without the disadvantages of open ditches.

Drainage benefits farm crops in several ways. Because drained soil can be worked early in the spring, crops in it get an early start. Because drained soil becomes warm sooner, and admits more air than wet land, a higher percentage of seeds germinate in it. Because drained soil causes roots to grow deep, they gather more plant foods.

SOIL AND AIR.

EXPERIMENT 19-11. Does soil contain air?

Permit the soil in a flower pot to become quite dry. Place the pot in a saucer of water, and, at the same time, cover the surface of the soil with water. What causes the bubbles?

The air in soil is needed for several purposes. Seeds require it to germinate; roots need it to grow; bacteria must have it to live and to prepare food for other plants. By helping to warm the soil in spring, air speeds up all three of these processes.

Air usually makes up about one-half of the volume of well-drained and well-cultivated soils. Because the air spaces in sand are larger than those in clay soil, air circulates through sandy soils more freely than through clay soils. Nevertheless, when clay soil is kept well cultivated, its tiny, but numerous, air spaces contain plenty of air for plant roots. The amount of air in soil is increased by drainage, by the addition of humus, and by cultivation — especially soon after rains.

SOIL AND WARMTH. Soil must be warm for bacteria to thrive, for seeds to germinate, and for plants to absorb moisture. Some experiments will help us find out what conditions determine the temperature of soil.

EXPERIMENT 19-12. How does the amount of water in the soil affect the rate at which the soil becomes warm?

Put dry soil into one bowl and very moist soil into another. Place both in the same sunny window. In each, bury the bulb of a thermometer to the same depth. Read the temperature of the two soils each hour from 9 a.m. until 1 p.m. Which soil warms more quickly, dry soil or moist soil?

When there is a great deal of moisture in the soil, the sun must heat both the water and the soil particles. Therefore, well drained soils warm more quickly in spring.

EXPERIMENT 19-13. How does the colour of the soil affect the rate at which it becomes warm?

Place dark, dry soil in one dish, and an equal weight of light-coloured, dry soil in a similar dish. Insert thermometers into them as described in experiment 19-12 and continue the experiment as you did then. Which soil absorbs heat more readily, dark soil or light-coloured soil?

Well-drained soils containing much humus warm quickly because they are dark in colour. If they are kept loose enough to let air enter and circulate freely through them, they will become warm even more quickly.

SOIL AND BACTERIA. Every thimbleful of ordinary soil contains millions of tiny living plants, called bacteria. These require food, moisture, air, and warmth. They obtain food from plant remains in the soil, and moisture from water between soil particles. Most well-drained soils contain sufficient air and warmth for soil bacteria to live, work, and multiply. Some of the bacteria change plant and animal remains to humus; others change this humus to plant foods ready to be absorbed by new crops.

The roots of clover, alfalfa, peas, and other such pod-bearing plants, called *legumes,* usually bear little knobs (*nodules*) containing many special bacteria. These bacteria are able to take nitrogen from the air in the soil and change it to chemicals that the roots can absorb as plant food.

ACID AND ALKALI SOIL. Some soils are described as *sour* or *acid*. These soils contain acids, substances that, like vinegar, taste sharp and sour. We know that a substance is acid if it changes blue litmus paper to red.

EXPERIMENT 19-14. Test some soil to find out whether it is acid.

Mix the soil with enough water to make a paste. Make a knife-cut in this and insert a piece of blue litmus paper. If the paper becomes red in about 10 minutes, the soil is acid.

Acid soils prevent bacteria from working efficiently to change vegetable matter into humus and plant foods. Clovers grow poorly in acid soils, but mosses thrive in them.

Poorly drained soils, and those that lack limestone, are frequently acid. They may be improved by draining the soil and by adding ground limestone to it.

Some soils, particularly in Western Canada, are known as *alkali soils*. They contain substances called *salts*. These salts can be removed by thoroughly draining the soil. This lets the water dissolve the salts and carry them away.

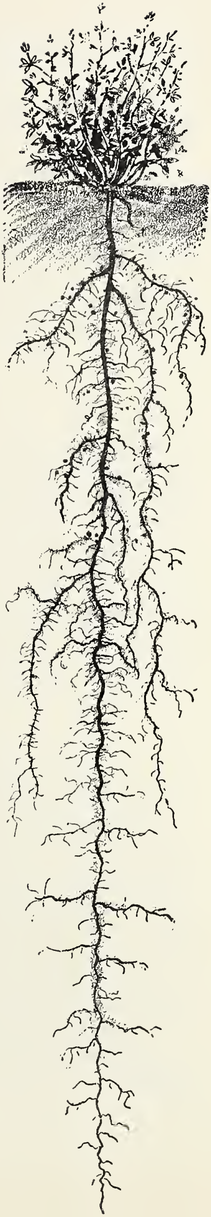


FIG. 19-11. NODULES ON THE ROOTS OF A CLOVER PLANT.
Thousands of useful bacteria live in these nodules, shown as black knobs in this drawing.

A Review

The amount of food made by garden and farm crops depends upon several factors. The soil must contain enough of all the minerals needed by the special crops. There must be the right amount of water in the soil both to feed the plants and to carry dissolved minerals into them. Air must circulate through the soil to the roots to permit them to breathe. The soil, with the water and air in it, must be warm enough for the roots to absorb nourishment for the plants. Bacteria must live and work successfully in the soil to change decaying plant remains into plant food. For the health of the bacteria and most other plants, the soil must not be too acid. Under these conditions green plants grow strong and healthy. Healthy soil and healthy plants will lead to healthy farm animals and healthy people.

For Oral Discussion

1. Describe each of the following materials: loam, gravel, clay, silt, mulch, humus.
2. What purposes do bacteria in soils serve?
3. What conditions in soil are not favourable to bacteria?
4. What conditions cause soil to become acid?
5. The moon is thought to have no atmosphere around it. Why, then, would the rock on it not be weathered to form soil?
6. Describe three ways in which weather and climate help to change rocks to soil.
7. Tell how plants and animals change soils.

For Written Answers

1. Name three kinds of rock particles found in ordinary garden soil. Compare them in size.
2. Soils may be described in these terms: (a) easy to cultivate, (b) airy, (c) rich in plant foods, (d) sticky when wet, (e) hard when dry, (f) retain water well, (g) good for market gardening, (h) light, (i) heavy. List the five main kinds of soil one under the other. After each, write the letters (a), (b), (c), etc. which indicate, as shown above, facts true of that soil.
3. Name three conditions in soil that favour the growth and work of soil bacteria.
4. What effect has acid soil upon litmus paper?
5. What may be added to an acid soil to counteract the acids present?

Read

Compton's Pictured Encyclopedia: "The Life-Giving Soil", Vol. 13, pp. 226-231.

16 mm. Sound Films

Our Soil Resources (SG-42)
Birth of the Soil (SG-40)
Ontario Visual Education Branch.

Film Strips

How Soil Is Formed
Water and the Soil
Minerals and the Soil
Plant Life and the Soil
Animal Life and the Soil
How Man Uses the Soil
General Films Limited, Toronto.

20

SAVE THE SOIL

THE FERTILE TOPSOIL is the world's most precious treasure house. These top few inches feed and clothe the peoples of the earth. In Canada, when the pioneer farmers cut the virgin forests and ploughed under the prairie grasses, the topsoil was rich enough and deep enough to yield abundant harvests. Before that time it had been protected and enriched throughout the centuries by its cover of trees and grass. Since then, it has gradually become thinner and thinner, and less and less capable of producing good crops.

Every particle of soil that has been washed away by water or carried away by wind has left the layer of topsoil thinner. All the plant foods dissolved from soil by water running over or through it have left it less fertile. We must find ways of saving the soil from such unnecessary losses.

Erosion: Enemy of the Soil

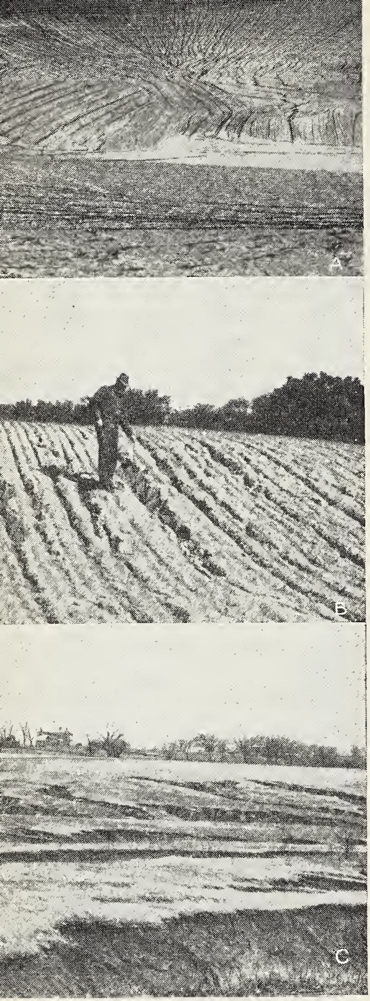
Water and wind are the soil's worst enemies when they loosen and carry away fertile topsoil. Both are likely to take from the land the lightest and finest particles of soil. The lightest particles are usually decayed plant remains, and the finest particles are silt and clay, the two parts of the soil most useful to plants. Erosion, therefore, whether by wind or water, makes the topsoil both thinner and less fertile. Soil maps show that more than half of the farm land in Ontario has suffered in these ways from erosion.

SIGNS OF EROSION. Muddy water is always a sign of erosion, for it shows that the water has loosened and carried away some soil. When we see little ditches in fields, or bigger ones, called *gullies,* in fields or along roadsides, we know that run-off water has taken away much soil with it. A layer of gravel or stones on the top of soil, or an exposed area of rock, is evidence that water has washed away the finer particles of soil that lay over or between them. Sediment deposited on flat lands below a hill, or in ponds and water holes, shows that soil has been eroded and carried away by water from other places.

Erosion by wind can be detected both where soil has been taken away and where it has been deposited. Stones and gravel on the surface of soil, exposed roots of trees, and bare spots in meadows or pastures usually indicate that some soil has been blown away. Little drifts of soil, and those large enough to be called *sand dunes,* show where soil, eroded by wind, has been dropped. Even the dust that blows into our eyes or settles throughout the house may have been soil in some fertile field.

EROSION BY WATER. Erosion by water begins on hilltops or hillsides and continues until the water enters the sea. It takes place wherever water flows fast enough to move particles of soil. The rate of erosion depends upon the kind of soil, the amount and kind of plant life growing on it, the heaviness of the rainfall, and the steepness of the slope. When erosion gradually removes thin layers or sheets of soil from the whole surface of the field, we call it *sheet erosion;* when the water gathers in little rills which cut small ditches in the soil, we have *rill erosion;* and when it digs out deep ditches, *gully erosion.* Study fig. 20-1 as you read further.

Sheet Erosion. Water erosion begins with the splash of rain-drops loosening some bare soil. The water that does not soak



into the soil flows over it in a broad sheet, taking a little soil with it. The amount of soil thus carried away may be so slight that it remains unnoticed for several years. However, when we consider that nature took thousands of years to form the six inches of topsoil that sheet erosion can steal in one man's lifetime, we realize what an enemy erosion can be.

PUPIL INVESTIGATION. How does grass reduce erosion by raindrops?

Place one board on a bare spot and a similar one where there is a dense growth of grass. After a rain, notice how the soil has been splashed on each. Explain the difference.

Rill and Gully Erosion. Sooner or later run-off water collects in little streams, called rills, each digging a little ditch as it goes. Sheet erosion has then become rill erosion. Several little rills may come together to form a larger rill, just as tributaries join to form a river.

The ditches dug by such bigger rills gradually become large enough

Fig. 20-1. Three Types of Water Erosion.

A. Sheet erosion, like this, carries away surface water and fertile topsoil.
B. As sheet erosion continues, the tiny streams become larger ones, called rills. Then we have rill erosion, as shown here, causing greater loss of water and soil.
C. The rills wear deeper channels, called gullies. These carry away a great deal of water and soil and make the area useless for agriculture.

to be called gullies. With each rain, the water that spills into these gullies from their ends and sides cuts them longer, wider, and deeper. Soon the gullies reduce the crop area of the field and make the remainder of it difficult and dangerous to cultivate, are shown in Fig. 20-1, C.

We can control and cure gullies. Trees and shrubs planted along their sides will keep them from becoming wider. Brush, stones, and other rubbish, thrown into the gullies, will prevent water from wearing them deeper. We can cover these materials with soil, then seed it to grass. Examine fig. 20-2.

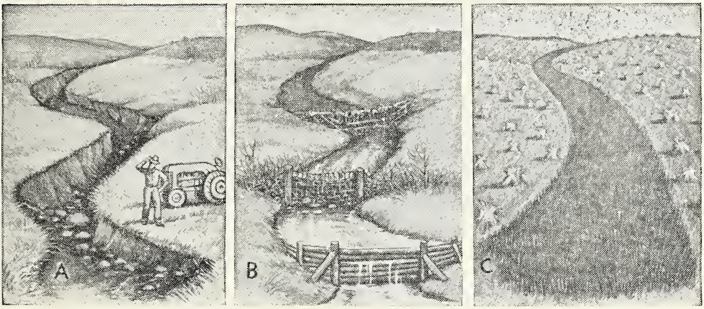


FIG. 20-2. THE STORY OF A GULLY.

A, a deep, wide gully winding through a field and hindering the operation of farm machinery; B, three kinds of dams that break the flow of water through a gulley: a log dam; a dam consisting of wire, brush, stones, and rubbish; and a dam made of sticks, brush, and straw; C, a grassed waterway resulting from filling, levelling, and seeding a gully after the rush of water had been stopped.

It is better to prevent gullies from being formed than to cure them later. Run-off water always flows through valleys or waterways in the low-lying parts of a field. It will flow over these waterways instead of wearing ditches in them if we make them *grassed waterways,* that is, if we keep them growing a tough layer of grass. Running water flattens the grass ahead of it, forming a protective mat over which it flows. Farmers must be careful not to permit machinery to damage the grass in such waterways, or the water will soon begin to dig a gully. Grassed waterways through fields are not wasted land, for the grass in them may be harvested as hay (fig. 20-3).

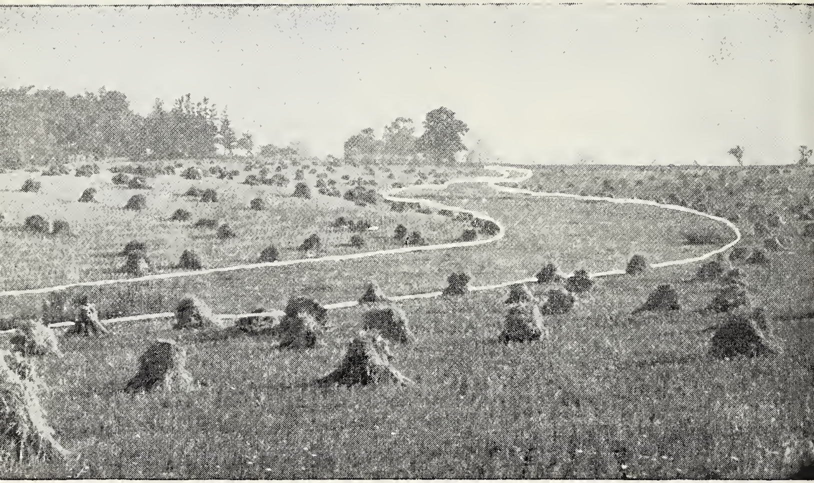


Fig. 20-3. Preventing Erosion on a Canadian Farm.
The natural waterway (outlined in white) through this grain field is kept permanently in grass to prevent water from wearing away soil.

Excursion To Study Erosion

1. Explore the neighbouring fields, roadsides, pastures, and home surroundings to discover gullies formed as follows:
   (a) where water drips from the eave of a building;
   (b) along furrows or cultivation markings up and down a hill;
   (c) where cows or sheep have made paths in pastures;
   (d) where wheels have left their marks down a slope.
   These are four common causes of gully erosion.

2. Make a drawing of a gully and the land around it. Measure and label the width and depth of the gully. Correct your drawing after the next heavy rain.

WE MUST CHECK WATER EROSION. Millions of dollars worth of Canada's most fertile topsoil is carried down our rivers every year. As the layer of cultivated topsoil becomes thinner, crops become poorer. While being carried away, the lost soil makes our streams muddy, kills fish and other water life, and leaves bathing beaches unfit for use. When this soil settles from the water, it fills our lakes, reservoirs, and harbours with silt. Investigations showed that during one spring day the Humber River carried fertile soil from farm fields into Lake Ontario at the rate of 2,700 tons an hour, or about as fast as a close procession of one-ton trucks could transport it. To stop such losses we must find ways of checking erosion by water.

HOW WE MAY CHECK WATER EROSION. The two main ways of preventing water from carrying away fertile soil are (1) protecting the soil by means of trees or grass, and (2) cultivating the soil by special methods which prevent water from running over it instead of soaking into it.

Trees and Grass on Hilltops and Slopes Check Erosion. Any vegetation helps to prevent erosion. Thus it conserves both soil and water. By breaking the fall of raindrops and keeping them from starting to run down a hillside, vegetation makes more of the water soak into the ground. Beneath the surface the roots also help to hold the soil in place. Therefore, it is easy to understand how cutting the forests and ploughing under the grass on sloping land caused erosion to increase immensely. Fortunately, we can check this erosion by growing more trees and more grass.

Now review fig. 7-3.

PUPIL INVESTIGATIONS. Find evidences that vegetation checks erosion.

After a heavy spring rain visit hillsides which are wooded, others which are grass-covered, and others with bare soil. Near each, look for the following evidences of erosion: muddiness of nearby creeks, damp soil heaped at the base of the slope, soil clinging to grass, and gullies dug out. Compare the amounts of erosion under the three conditions.

Forests are needed to conserve both soil and water, especially on hilltops and steep slopes. In such places new forests should be planted if the original ones have been cut. To check erosion, both old and new forests need healthy seedlings and young trees. These can thrive only if we keep cattle from pasturing in forests and woodlots. Not only do forests on hills prevent loss of soil by erosion; they keep making new fertile soil. They also store up ground water which can feed wells, springs, streams, and crops on lower lands.

Grass is almost as valuable as trees and shrubs in protecting soil from erosion. We learned in an earlier chapter how grass blades cause rain to soak into the soil instead of running off, and how the close-growing roots hold the soil in place. Land that slopes enough for water to run off easily, but that is not steep enough to require forest protection, should be left in permanent pasture or used to grow hay or pasture as much of the time as possible.

Even those slopes that must be kept cultivated for other crops may be protected from erosion in late fall, winter, and early spring by sowing them to fall rye in early autumn. Like grass, this temporary crop keeps the soil from being washed or blown away. In the next section we shall learn how alternating strips of grass across slopes help to conserve both soil and water.

Experiments have been performed to measure and compare the amounts of soil and water lost from grassy fields with the amounts lost from cultivated fields. All the water running off from two equal areas with the same slope, one in grass and one cultivated, was caught in large tanks. Both the amounts of water that ran off and the amounts of soil carried off by this water were measured. This experiment showed that the cultivated soil lost 400 times as much soil as the grass-covered soil. In France and England long experience has shown that it pays to leave three-quarters of the land in such close-growing crops as grass, clover, or alfalfa. Study fig. 7-3 again.

Special Methods of Cultivation Conserve Soils. Throughout the ages good farmers have tried to find better ways of farming.

More recently they have been helped by specialists in agricultural colleges and experimental farms. Among them, they have proved that the methods of cultivation described below help to prevent erosion by water and, at the same time, help to conserve water in soil.

Contour Farming. Cultivating and planting crops across a slope, or horizontally around a hill, instead of up and down its slope, is known as *contour farming.* Each row of crop and each little ridge left by the cultivating implement forms a tiny dam which causes water to soak into the soil, thus keeping it from flowing down the hill and carrying soil with it. When the rows of cultivator marks extend up and down the hill, the water from rain and snow gathers in the little grooves or valleys and runs freely down the hill, cutting little gullies and carrying away fertile topsoil. Cultivating on the level, following the contour of the hill, prevents erosion, conserves water, reduces wear on farm machinery, and gives better crops.

EXPERIMENT 20-1. Show how contour farming reduces erosion.

Make two mounds of topsoil in the yard. With a stick make furrows around one and up and down the other. Sprinkle the same amount of water over the centre of each mound. Compare the amounts of water that run off each, also the amounts of soil carried from each. Why does cultivating around a hill reduce run-off and erosion?

One heavy rain carried away eight times as much soil per acre from a field of corn planted with the rows up and down the hill as it did from an adjoining field which had the same slope but had corn planted in rows around the hill. At the same time the first field lost much more water.

Strip Cropping. To prevent erosion by wind and water on sloping, cultivated fields, good farmers often plant their crops in strips. These extend across the slope in the same direction as the contours in contour farming. One strip is used to grow grain or a cultivated crop such as potatoes; on the next strip on either side is grown a crop of clover or grass. The water from a cultivated strip, and the soil carried away with it, are both caught by the dense vegetation in the next strip. This enables the water to soak into the soil where it is useful to plants, and prevents the fertile topsoil from being carried farther. The next year the farmer rotates the crop so that each strip takes its turn at growing grain, hoed crops, and grass. Fig. 20-4 will help you to understand this better.

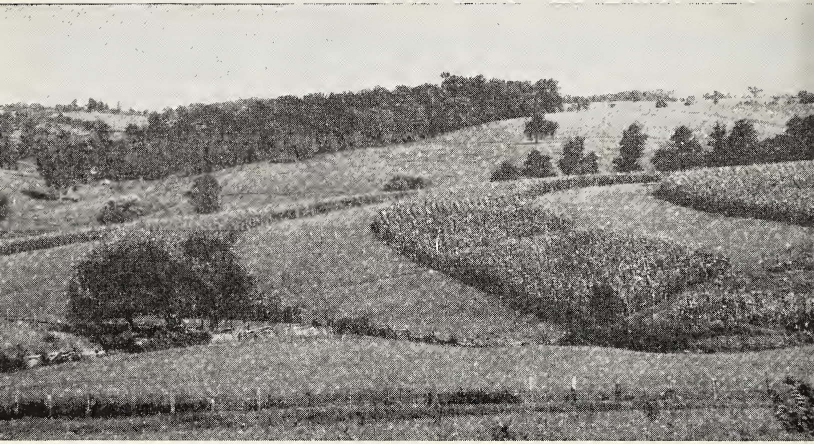


Fig. 20-4. An Excellent Illustration of Contour Strip Cropping. The strips of grass (meadow) between the strips of corn on this sloping field catch any water and soil that may run off the cultivated soil on which the corn is growing.

In many parts of Europe strip cropping has been practised for hundreds of years to check erosion of soil.

Terracing. Terraces in fields are something like terraces in lawns. Instead of leaving one long, gradual slope, we make several wide steps, called terraces. Each terrace consists of a comparatively level area separated from the next by a steeper bank. Pictures often show Chinese rice fields on level steps, one above the other, on long hillsides.

Terraces on hilly fields go across the slopes or follow their curves as contours do. The bank at the lower edge of each terrace is a low ridge, above which is a shallow channel to

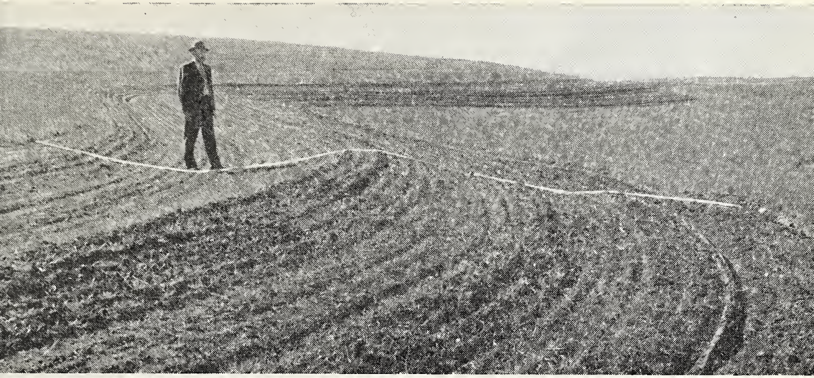


Fig. 20-5. Terraces Prevent Erosion by Water.

The curving white line beside the man shows how this field has been cultivated in terraces. The ridge to the right of the man prevents water from running farther down the hill and carrying away fertile soil with it.

catch run-off water. The ridge keeps the water from running down the full length of the hill and carrying good soil with it. Each terrace is planted to a crop by itself. See fig. 20-5.

The Incas of Peru terraced their steep hillsides for many centuries to conserve water and to prevent it from carrying away fertile soil. Terraces in the vineyards of Southern France serve the same purposes (fig. 20-6).

Stubble-mulch Farming. Decaying plant materials, left as a mulch on the surface, or mixed with the top layers of soil, save both soil and water. By helping the soil to absorb more moisture, they reduce the amount of water that runs off taking good soil with it. In winter the mulch holds drifting snow. When this melts, it adds water to the soil. For these reasons, many farmers use cultivators or disks (fig. 20-7) which stir the soil and mix stubble and other refuse loosely into it close to the surface instead of ploughing them under in the bottoms of the furrows. As the plant materials decay near the surface,

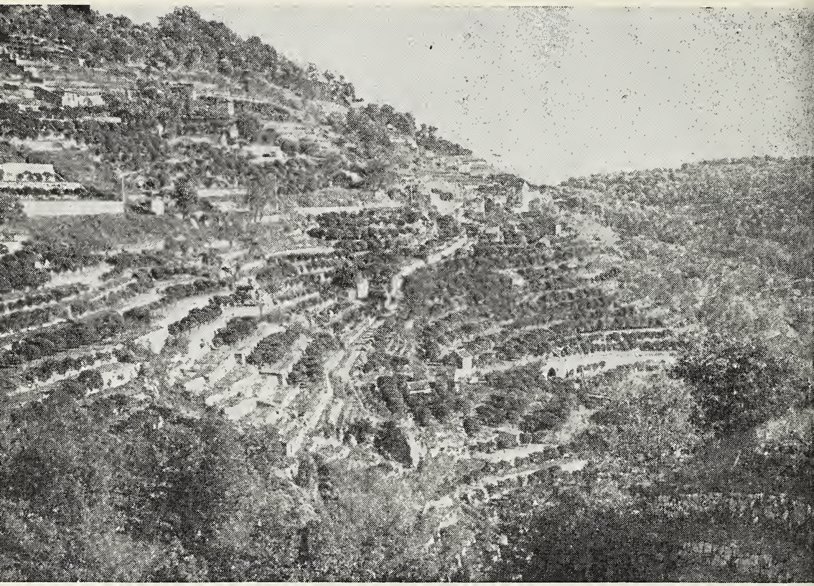


FIG. 20-6. CITRUS TREES GROWING ON TERRACES BUILT ABOUT 2,500 YEARS AGO IN SOUTHERN FRANCE.

Study the retaining walls and the gently sloping areas above them. Notice the homes, barns, and roads throughout the terraced area. Imagine how steep, bare, and eroded this hill would be if there had been no terraces.

they make the soil looser, more fertile, and better adapted to absorb and hold moisture.

EXPERIMENT 20-2. How does a cover of grass or refuse reduce the loss of water and soil?

Make two mounds of good garden soil, and smooth the surface of each. Cover one with grass clippings, fine straw, or refuse. Leave the other bare. Sprinkle equal amounts of water on the centre of each. Compare the amounts of water and of soil lost by each. What would be the value of keeping the soil on hillsides covered with grass or crop refuse?

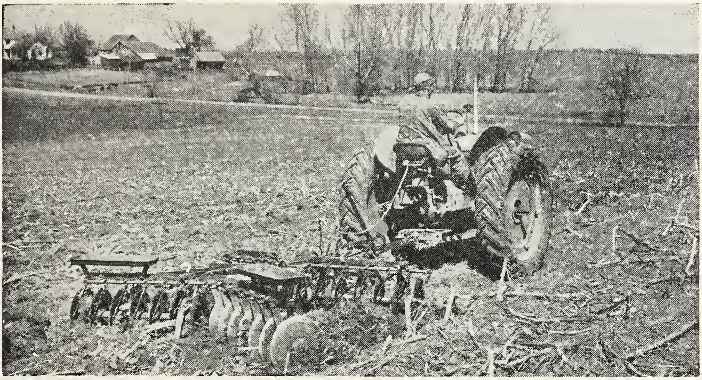


FIG. 20-7. STUBBLE-MULCH CULTIVATION.
Discing corn stubble into the top layers of soil to help prevent erosion by water and by wind.

A Local Survey

Visit farms on which contour cultivation and strip cropping are practised. Ask how contour cultivation saves labour, and how it reduces erosion. Find out: what crops are grown in alternate strips; how the roots of the close-growing crop hold the soil; and how the tops of this crop collect soil that washes from the cultivated crop.

EROSION BY WIND. When the first white men settled in the Canadian Prairies, they found the same wide, grassy plains that had long been the home of wild buffalo. For the new-comers, the luxurious grass became the pasture of great herds of cattle. When ploughed and cultivated, the fertile prairie soil produced rich crops of wheat and oats.

FIG. 20-8. A CLASS STUDYING THE RESULTS OF WATER EROSION.
Seeing is believing. The place to study erosion is where it occurs.

In many regions the new farmers gave too little heed to the lack of rain and the sweeping winds. Pastures, grazed too close, became tramped by the hoofs of the cows into dry, powdery soil. Cultivated fields no longer had the tops and roots of grass plants to hold the soil in place. Where the rainfall was light, the winds soon started to carry away the dry, loose soil.

As larger areas of prairie became cultivated, wind erosion developed into great dust storms. These blew away the finest and richest topsoil, leaving farms on which neither rain nor irrigation could cause crops to grow.

In the dry years before 1941 the dust storms in the Canadian West caused farm lands capable of producing more than 50,000,000 bushels of wheat per year to be abandoned. When topsoil is blown from one acre of land to a depth of one inch, it takes with it enough plant food to grow nearly 500 bushels of wheat.

Wind erosion is harmful in other ways. It uncovers and kills germinating seeds of grains and vegetables. Blown through the air, the dust hampers the breathing of both plants and animals. Where the soil is dropped by the wind, it may cover and kill grass and other crops. Elsewhere it may bring misery to people and livestock by penetrating homes and other farm buildings. Drifts of blown soil may cover or block roads and railways. Such are the penalties of ploughing large areas of land which nature meant to remain in forest or grass.

HOW WE MAY CHECK WIND EROSION. The methods used to keep wind from blowing soil away are similar to those used to keep water from washing it away. Among these methods are: keeping the soil covered with living trees or grass, strip cropping, and protecting the surface of the soil with a covering of plant remains.

Grass plants prevent wind erosion. The parts above ground break the force of the wind, and the densely-matted roots hold the soil in place.

If the grass is to prevent erosion efficiently, it must not be pastured close to the ground. When grass is short, the hoofs of grazing animals soon wear away the grass plants and loosen the soil, permitting the wind to start blowing it away.

Strip cropping of fields checks wind erosion. The larger the area over which the wind can sweep, the more strongly and swiftly it blows, and the more soil it can pick up and carry away with it. A strip of grass or hay between two strips of cultivated land stops the force of the wind so much that it picks up very little of the soil, even if it is loose and dry, as it blows over the narrow, cultivated areas.

Trees may serve as a windbreak. When planted in rows or clumps, close together, trees break the force of the wind passing over them. Having passed over the trees, the wind will not for a considerable distance blow close enough to the ground or strong enough to pick up soil. Thus, a windbreak prevents wind erosion on an area of land many times as large as that covered by the clump of trees. Windbreaks should be planted on the side of a field from which the wind usually blows. Review these facts by examining fig. 17-10 again.

A layer of stubble or other dead vegetation on the land, or cultivated loosely into its surface, keeps the wind from picking up soil, much as it prevents erosion by water. An experiment will help you to understand this.

EXPERIMENT 20-3. How does dead vegetation affect wind erosion?

Place equal-sized piles of the same kind of very dry soil in a windy place. Cover one with grass clippings, dead leaves, or other garden refuse. Examine the piles after a few hours. From which did more soil blow away? Review fig. 20-7.

Repeat the experiment, occasionally sprinkling one pile with water instead of covering it. What effect would irrigation have upon wind erosion?

Land that has been badly eroded by wind can be restored to vegetation. In regions that originally were forested, evergreen trees are planted. On areas which once were grass-covered, but which are not fertile enough now for pasture grasses to get a start, varieties of tall, tough grass are grown temporarily to break the force of the wind and prevent further erosion. These hold the soil in place until grasses more useful for grazing can be grown again. Turn back and study fig. 17-1.

Erosion in History and in the Future

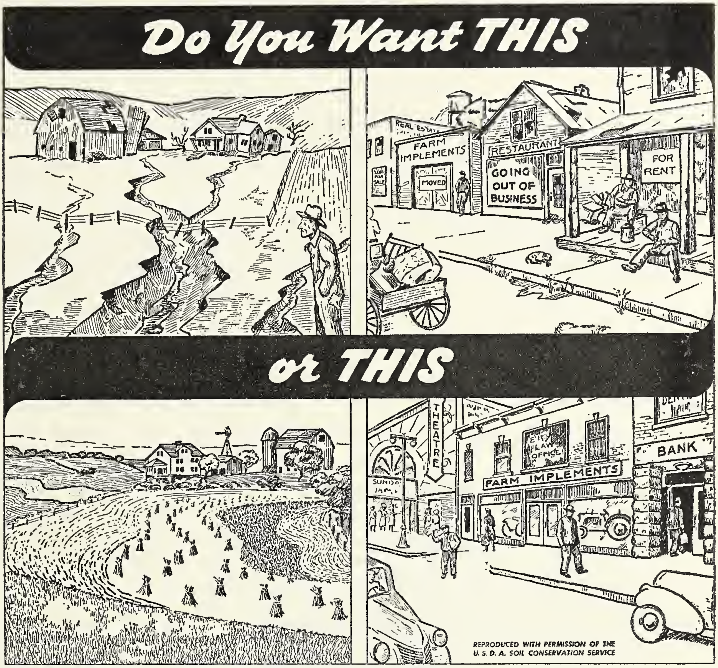
LESSONS FROM THE PAST. The rise and fall of great empires and nations often has depended upon fertile topsoil and upon how it was conserved or destroyed. Five thousand years ago the valley of the Tigris and the Euphrates rivers was one of the most fertile farming regions in the world. Forested highlands kept the rivers filled with water the year round, always providing enough for the irrigation systems. As the population increased, men cut the forests for farm land. Then the rivers became flooded in spring, and the irrigation systems dried up in summer. Wind and water carried away the topsoil from hillsides cleared of forests and from overgrazed pastures. Gradually the whole valley, often called "The Garden of Eden", became a desert, providing the mere necessities for a population less than one-tenth of what it had been before.

Erosion changed "The Promised Land" of three thousand years ago, described by Moses as "a land of brooks and water . . . of wheat and barley and vines and fig trees", to one of bare hillsides and abandoned village sites.

The coastal regions of North Africa once supplied most of the grain needed by the mighty Roman Empire. Man cut the forests, and wars wrecked the irrigation systems. Then, after wrong methods of cultivation had been followed, windstorms carried away the fertile soil — leaving desert wastes.

History teaches us that erosion by water and wind can make farms uninhabitable, destroy nations, and cause the fall of empires.

WHAT OF TOMORROW? Many areas in Canada can suffer the same fate as have Northern Africa and Palestine unless everything possible is done to keep topsoil from being stolen away by wind and water. Canada's precious topsoil, the nation's most important natural resource, will be saved only by what we *do*, not by what we *know*.



REPRODUCED WITH PERMISSION OF THE U. S. D. A. SOIL CONSERVATION SERVICE

FIG. 20-9.

What *can* we do to help save our soil? We can try to prevent good soil from being eroded from our grounds and gardens at home and at school. If we live on a farm or a market garden, we can try to persuade those who work the land to discover the best ways of conserving the topsoil, then practise these ways. We can let others know about motion pictures, talks, bulletins, and circulars prepared by Provincial and Federal Departments of Agriculture, by organizations of naturalists and sportsmen, and by any other people who are trying to conserve our soil.

Soil conservation is everyone's responsibility. We must all learn about it and work for it. The future of Canada is at stake! Will you do all you can to help *save the soil?*

Excursions To Study Erosion

Where To Go	What To Do
1. To a gully after a heavy shower	Find where the gully started, in what ways it is enlarging, and what its future probably will be.
2. To an area of level land at the foot of a cultivated hill	Find topsoil washed from the slope. Notice its depth, signs indicating how it got there, and whether it is topsoil or subsoil. Measure the depth of the topsoil on the slope and at the foot of the hill.
3. To a stream containing water from a cultivated field soon after a rain	Notice the muddiness of the water. Collect a jar of it and let it settle.

Things To Do

1. Carry out one or more *Save the Soil* projects such as: cultivate the school garden on the contour; repair a gully; terrace a cultivated hillside; make a grassed waterway by sodding or seeding a valley at home or at school.

2. Arrange a "conservation shelf" in your school library. Include on it books, circulars, bulletins, maps, pictures, and your own reports.

3. Arrange for classroom and community use of motion pictures, film strips, and lantern slides to explain how to conserve soil.

4. Make a survey of the needs for soil conservation and of steps that have been taken to conserve soil in your community. Organize the class into groups or committees. Interview local farmers and others interested in conserving soil, and invite them to talk to the class. Take field trips to observe grassed waterways, contour cultivation, strip cropping, and plantings in gullies.

5. Find how deep the topsoil is along a fence and in a cultivated hillside nearby. Account for the difference. Try to find out how many years the field has been cultivated. How many years did it take for an inch of topsoil to be washed away?

6. Make a sandtable scene of a farm to illustrate: wooded hills, grass-covered slopes, a gully, erosion on a slope cultivated up and down, absence of erosion with contour cultivation and strip cropping.

7. Let some muddy water from a stream stand until all mud has settled out from it. Measure the amount of soil. Calculate how much of this would be carried from an acre of land if one inch of equally muddy water ran off into the stream.

A Review

Study and compare figures 20-10 and 20-11.

Facts Worth Remembering

1. Vegetation prevents erosion by: reducing the splash of raindrops, helping rain to soak into the soil, anchoring the soil by roots, and breaking the force of the wind.

2. Most erosion has been caused by: cutting forests, breaking the prairie, and cultivating hillsides.

3. Sheet erosion slowly removes good soil, makes the layer of topsoil thinner, covers crops on low lands, uncovers seeds, washes out growing crops, makes streams too muddy for fish, prevents healthful bathing, fills harbours with silt, and increases flood waters.

4. Wind erosion takes away the finest and best topsoil, reduces soil fertility, uncovers seeds, covers growing crops, fills roads with drifting sand, and carries dust and sand into our homes.

Test Questions and Exercises

1. How does each of the following affect the amount of erosion by wind or water: the slope of the field, the density of the vegetation, the amount of humus in the soil, the heaviness of a rainfall?

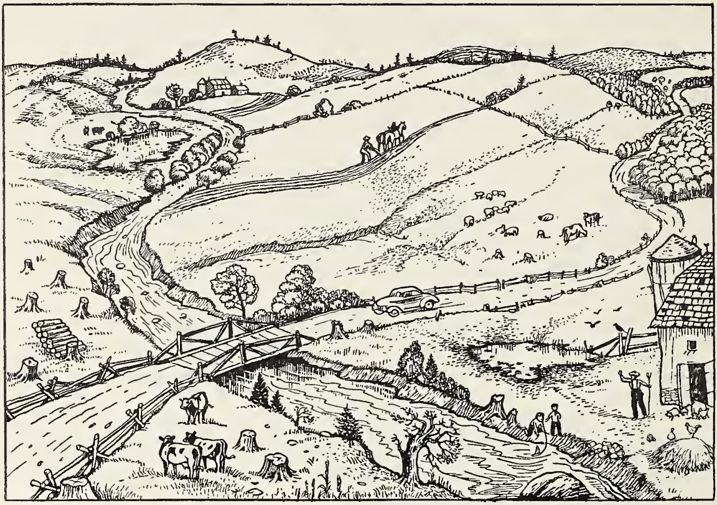


FIG. 20-10. POOR FARM PRACTICES CAUSE THE RUN-DOWN CONDITION OF THIS FARM.

Find: eroded, bare stream banks; up-hill and down-hill ploughing; gullies in the pasture field; hilltops cleared of forests; useless water holes.

2. How does each of the following help to prevent erosion by wind or water or both; forests on steep slopes, grass on gradual slopes, grassed waterways, contour cultivation, strip cropping, terracing?

3. Why is it better for a farmer: (a) to leave the surface of a sloping field rough rather than to harrow it smooth? (b) to mix stubble and other field refuse throughout the soil by thorough cultivation rather than to plough it under?

4. Give three reasons why a heavy rain causes more erosion than a steady one.

5. List these crops in order of importance in preventing erosion: corn, oats, woodlot, grass.

6. During one heavy storm, water carried away 20 tons of topsoil from each acre in a sloping field. How many tons would be washed away from 100 acres? How many two-ton truck loads? What would be its value at three dollars per ton?

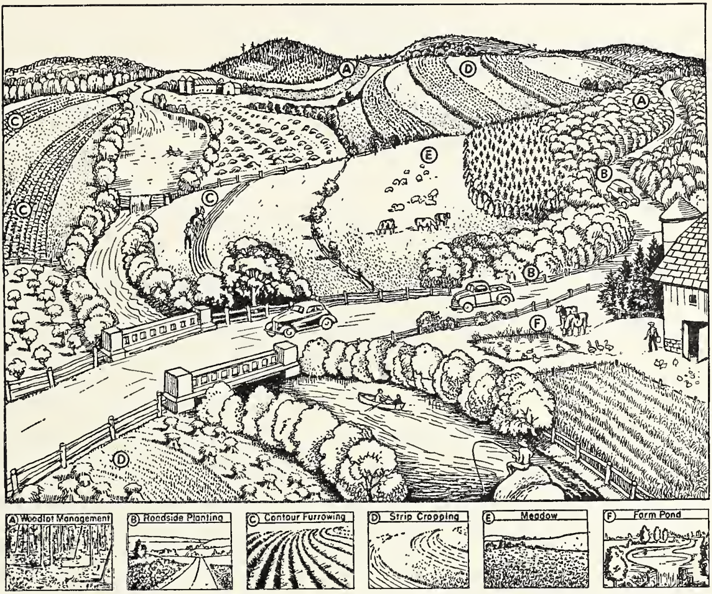


FIG. 20-11. GOOD CONSERVATION FARMING FOR A FEW YEARS WOULD CHANGE THE FARM SHOWN IN FIG. 20-10 TO A VALUABLE, PRODUCTIVE FARM AS SHOWN HERE.

Find examples of the good farming practices illustrated in the small drawings at the bottom of this figure. Look for other examples of each of these conservation practices. Find the following farm improvements which did not appear in fig. 20-10: a dam to conserve water, trees to prevent stream-bank erosion, repaired gullies, an orchard, and renovated buildings.

◆

16 mm. Sound Films

Erosion by Wind and Water (SG-8)
Rape of the Earth (SG-43)
Ontario Visual Education Branch.

Land in Trust
Soil for Tomorrow (colour)
National Film Board, Ottawa

Battle against Erosion
United Kingdom Information Office, Ottawa.

Film Strips

Saving the Soil (colour)
Ryerson Film Service, Toronto.

Soil Conservation
Canadian Film Institute, Ottawa.

How Man Conserves the Soil
How Long Will It Last?
General Films Limited, Toronto.

Seeds of Destruction (SG-44)
Soil Conservation
Canadian Film Institute, Ottawa.

21

MAKE THE SOIL MORE PRODUCTIVE

> Whoever could make two ears of corn, or two blades of grass, to grow upon a spot of ground where only one grew before, would deserve better of mankind, and do more essential service to his country . . . .
>
> *Gulliver's Travels*

BETTER AND BIGGER HARVESTS, from richer soil, are needed to feed the world's growing population.

Early farmers could find and settle on new land when theirs had been made too thin by erosion, or had lost its fertility by poor methods of farming. Today's farmers cannot do this, for most of the desirable new land has been settled. To meet the increased demands for farm products, they must make the soil they now have produce bigger and better crops. In addition to preventing the fertile topsoil from being washed or blown away, farmers must both conserve and increase its fertility.

Characteristics of Good Soil

We call soil "good" when it produces crops that are big and that also provide foods that are healthful for man and his livestock. Healthful foods must contain all the substances needed to build bones and other body tissues, produce body heat and energy, and keep all parts of the body working smoothly. They must provide also the vitamins needed to prevent diseases. For example, if soil lacks calcium and phosphorus, so will the grass which grows on it, the milk produced by the cows that eat the grass, and the teeth and bones of those who drink the milk.

GOOD SOIL PROVIDES PLANTS WITH THE NECESSARY PLANT FOODS. All green plants must have the following ten elements to grow well: carbon, oxygen, hydrogen, nitrogen, phosphorus, potassium, calcium, iron, magnesium, and sulphur. Of these, the carbon and some of the oxygen are provided by the leaves from carbon dioxide in the air. The hydrogen, and more oxygen, are provided by the water taken in by the roots from the soil. The remaining seven elements are supplied by the minerals or by vegetable matter in the soil.

Good soil provides plants with the right amounts of water and air. When there is too little water in soil, plants cannot take in as much as they need for food, neither can they absorb enough dissolved mineral matter from the soil. When soil contains too much water, the air needed by living roots cannot pass through the soil to them, neither can soil bacteria obtain the air they need to breathe. Loam and clay loam are the best soils for most plants because they provide the right amount of moisture and, at the same time, admit air freely.

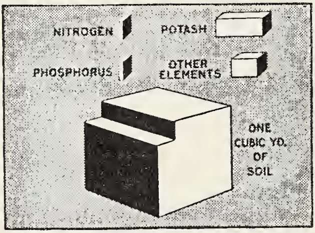


FIG. 21-1. RAW PLANT FOODS FOUND IN SOIL. This drawing shows what a small proportion of fertile soil is made up of mineral foods ready for plants to take in. When soil does not contain enough of these three elements to cause plants to grow well, we should fertilize it.

Good soil provides plants with the necessary minerals in the right quantities. The minerals in the rock particles that make up most of the soil, and in decayed plant remains, are slowly dissolved in soil water. The solutions formed in this way are absorbed by the roots of green plants. Deep-rooted plants such as alfalfa get minerals from far down in the subsoil.

Each kind of mineral serves a special purpose in plant growth. Then each becomes a part of our food, whether it comes from plants or from animals that eat plants.

Calcium, needed by both plants and animals, is provided by fine particles of limestone in the soil. It feeds the plants, and also keeps the soil from becoming acid. It is especially essential for clovers to grow well. When cows eat clover, calcium becomes an important part of milk; when we drink milk, the calcium becomes an important part of our bones.

Potassium is necessary to keep plants vigorous and free from disease. By making stems stiffer, it helps to keep grain crops standing erect. It also enables plants to make more food, grow better, and produce plump seeds.

Phosphorus in soil helps young plants to form good roots and grow quickly. Later it helps them to produce flowers and fruits.

Nitrogen, although not a mineral, is one of the most important of all plant foods. Nearly all of it is provided by decaying plant remains in the soil. The chief work of nitrogen in the soil is to produce deep green colour in plants, and to promote the growth of leaves and stems. Therefore, it is

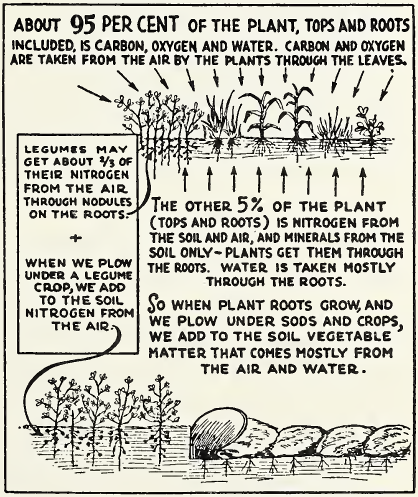

ABOUT 95 PER CENT OF THE PLANT, TOPS AND ROOTS INCLUDED, IS CARBON, OXYGEN AND WATER. CARBON AND OXYGEN ARE TAKEN FROM THE AIR BY THE PLANTS THROUGH THE LEAVES.
LEGUMES MAY GET ABOUT ⅔ OF THEIR NITROGEN FROM THE AIR THROUGH NODULES ON THE ROOTS.
+
WHEN WE PLOW UNDER A LEGUME CROP, WE ADD TO THE SOIL NITROGEN FROM THE AIR.
THE OTHER 5% OF THE PLANT (TOPS AND ROOTS) IS NITROGEN FROM THE SOIL AND AIR, AND MINERALS FROM THE SOIL ONLY – PLANTS GET THEM THROUGH THE ROOTS. WATER IS TAKEN MOSTLY THROUGH THE ROOTS.
SO WHEN PLANT ROOTS GROW, AND WE PLOW UNDER SODS AND CROPS, WE ADD TO THE SOIL VEGETABLE MATTER THAT COMES MOSTLY FROM THE AIR AND WATER.

Fig. 21-2.

used in large quantities by hay crops, pasture grasses, and such vegetables as lettuce, spinach, and cabbage.

Nitrogen makes up about three-quarters of the air both above ground and in soil. In chapter 19 we found out about the work of the bacteria in the nodules on the roots of peas, beans, clovers, and other legumes. These are very valuable to farmers because they can use nitrogen in the air in soil to make other substances that the roots can absorb as plant food. Similar substances containing nitrogen are produced in the soil when vegetable and animal remains decay.

These nitrogen-containing substances dissolve in the water in soil and are absorbed by the roots of plants. When they reach the leaves, they are made into plant foods. These later become a part of the roots, stems, and leaves. When the plants die or are ploughed under, and finally decay, the nitrogen in them becomes a part of the humus in the soil. Then other plants can use it as food.

GOOD SOIL CONTAINS MUCH HUMUS. Humus does much to make soil fertile. It is made chiefly from such materials as dead roots, leaves, stems, even fruits of plants, and from the dead bodies of earthworms and other animals that live in the soil. When covered by cultivation, or otherwise kept moist, these organic materials gradually decay, with the help of moulds and bacteria, to form humus.

Humus helps soil in several ways. It binds sandy soil, making it less easily eroded by water and wind. At the same time the humus enables the soil to hold more water. It makes clay soil loose and crumbly, more easily cultivated, and less likely to be sticky when wet, and hard when dry. Such clay soil will let water and air enter it more freely and pass through it more easily to the roots of the plants. When acted upon by bacteria, humus supplies soluble plant foods containing most of the nitrogen and minerals which plants need. To be fertile and, therefore, productive, soil should always contain much humus.

EXPERIMENT 21-1. What effect has humus upon plant growth?

Plant some bean or corn seeds in soil: (a) from the surface of a cultivated field; (b) from the floor of a dense forest; (c) from a valley into which soil frequently washes; and (d) from a fence corner where grass has grown for a long time. Compare the colours of the soils to determine the amount of humus in each. Judging by the growth of the plants, decide which soil is most fertile and which is least fertile. Explain your discoveries.

TO BE PRODUCTIVE, SOIL MUST BE IN GOOD PHYSICAL CONDITION. Soil that has grown grass for a long time is usually loose and mellow, and has an open, crumb-like appearance. This is because the particles of rock and of humus in it are grouped into tiny clusters. We say such soil is in good physical condition or has good structure.

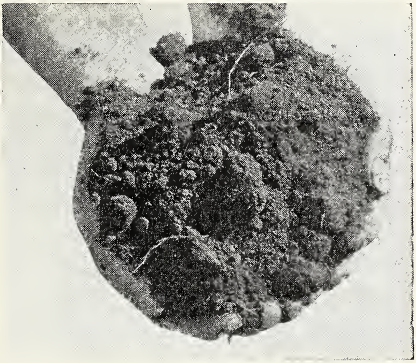


FIG. 21-3.
A HANDFUL OF GOOD TOPSOIL.
Notice the crumb-like appearance, the decaying roots, and the dark colour given to it by humus.

Soil in this good physical condition is cultivated without difficulty, and lets air and water enter and circulate through it easily. It holds much water, but does not become hard when dry. Roots pass through good soil with ease, grow well in it, and have no difficulty in getting water and food from it. Soil is easily kept in good physical condition if it contains much humus and is kept well cultivated.

LIVING PLANTS AND ANIMALS HELP TO MAKE SOIL PRODUCTIVE. Good soil is usually the home of many living things, both plants and animals. Those tiny plants that are called bacteria cause vegetable matter to decay and form humus. Then they set free the plant foods in the humus, making them useful to other plants. Still other small plants in the soil, known as moulds and fungi, help vegetable matter to decay and enrich the soil. Living roots of growing crops help to keep the soil loose enough to permit water and air to enter it freely.

PUPIL INVESTIGATION. Learn about the animal life in rich soil.

Collect some rich soil from a wood or from beneath a rubbish pile. Examine it for earthworms, ground beetles, ants, and other insects or insect larvae. Place the soil and animals in a glass jar. Keep the soil moist, and the jar screened and in a warm place. Study the activities of the animals. Name some of them. How do they help improve soil?

Earthworms are natural tillers of the soil. As they work back and forth between topsoil and subsoil, they constantly loosen the earth and mix these two layers. When the earthworm population is dense, they may bring to the surface as much as 15 tons of fine soil per acre each summer. Their burrows make it easier for air and water to reach the roots of plants.

Earthworms enrich the soil. When they cover bits of vegetable matter on the ground, or pull them into their burrows, they cause these remains to decay and become humus. When they die, their bodies, too, make the soil more fertile.

Earthworms help plants to get food from the soil. They eat much of the soil they remove to make their burrows. As the particles of rock and humus pass through their bodies, the digestive juices dissolve some plant foods from them and leave these ready for plants to take in.

Other animals such as moles, groundhogs, skunks, ants, and ground beetles help the soil in similar ways. Those that dig deep burrows mix more of the topsoil and subsoil. Those that live close to the surface constantly cultivate the soil and make it finer and finer. Like earthworms, these ground animals enrich the soil by covering vegetable matter. By loosening the soil, they help air and water to penetrate it.

How Soil Loses Fertility

The soil that the early pioneers cultivated after clearing the forests and breaking the prairie was richly supplied with humus and plant foods. It was good soil. Since pioneer days, some farmers have kept the soil fertile and good by using it wisely. Others have let it become less and less fertile by wasteful methods of farming. They grew crops without replacing the nourishment these took from soil; they let wind and water carry away good topsoil; they even let weeds steal useful plant foods.

CROPS MAKE SOIL LESS FERTILE. While crops are growing, they take plant foods from the soil. Pasture plants remove large quantities of nitrogen; barley uses much phosphorus; and most grains take large amounts of nitrogen and potassium from the soil. When farmers sell grain, hay, and vegetables, they are really selling the plant foods that were used to grow these crops, leaving the soil that much less fertile. When farmers, unwisely, burn crop refuse, they destroy plant foods which would make the soil more fertile if cultivated into it. Weeds, like crops, take plant foods from the soil, but they do not pay for them by yielding products useful to man.

FIG. 21-4. WHEAT-CLAD FIELDS IN WESTERN CANADA.

Both the grain and the straw of crops like this remove large quantities of plant food from the soil.

EROSION STEALS FERTILITY. Wind and water carry away the best soil. Water that runs off the soil dissolves and takes with it important minerals. See fig. 20-1.

EXPERIMENT 21-2. Does water that has run off or through soil contain any dissolved substances?

(a) Collect some water running over a cultivated field. Let the mud settle. Evaporate the water. Does any solid substance remain? If so, it must have been dissolved in the water.

(b) Punch holes in the bottom of a vegetable can. Nearly fill the container with garden soil. Add water until some escapes from the bottom. Catch this. Let it settle, then evaporate the clear water. Did the water contain any dissolved substances? If so, they were probably useful plant foods.

LEACHING REMOVES SOLUBLE PLANT FOODS. As water seeps down through and out of the soil in a field, it dissolves many substances that feed plants, and takes these beyond the reach of roots or out through drains. This is called *leaching*. Heavy rains cause gravelly and sandy soils to lose minerals in this way, especially when the soils do not contain enough humus to hold water well.

How Nature and Man Can Conserve Soil Fertility

Nature alone kept most of the original soil fertile. Man, too, can keep it that way by working in partnership with Nature and by following her methods.

NATURE ADDS HUMUS TO THE SOIL. Nature keeps the soil fertile by constantly returning to it the dead roots, stems, and leaves of plants, and the carcasses of worms, ground insects, and other animals. When these are acted upon by moisture and bacteria in the soil, they become humus, often called "the life of the soil".

Nature has many ways of adding humus to the soil. In forests, the fallen leaves, broken branches and twigs, and dead trees themselves all become humus. In fields and meadows, the dead tops of both annual and perennial plants, the dead roots that are constantly being replaced by new ones, and the whole bodies of plants that die outright are constantly decaying and adding humus to the soil. The blackness of the soil in prairies and grasslands, and in waste places or fence corners where natural vegetation is constantly dying and decaying, shows how efficient nature is in making humus from plant remains. See figures 21-3 and 15-10.

MAN CAN CONSERVE SOIL FERTILITY. In chapter 19 we thought of the soil as a great bank containing the riches of the nation. The wealth on deposit consists of minerals, decayed vegetation, humus, and water, all of which feed plants. To keep a bank account in good condition we must be sure that we do not withdraw from it more than deposit in it. To keep the soil from becoming less productive we must see to it that we do not take from it more plant foods than we and nature, working together, replace in it. There are several ways of maintaining the fertility of soil.

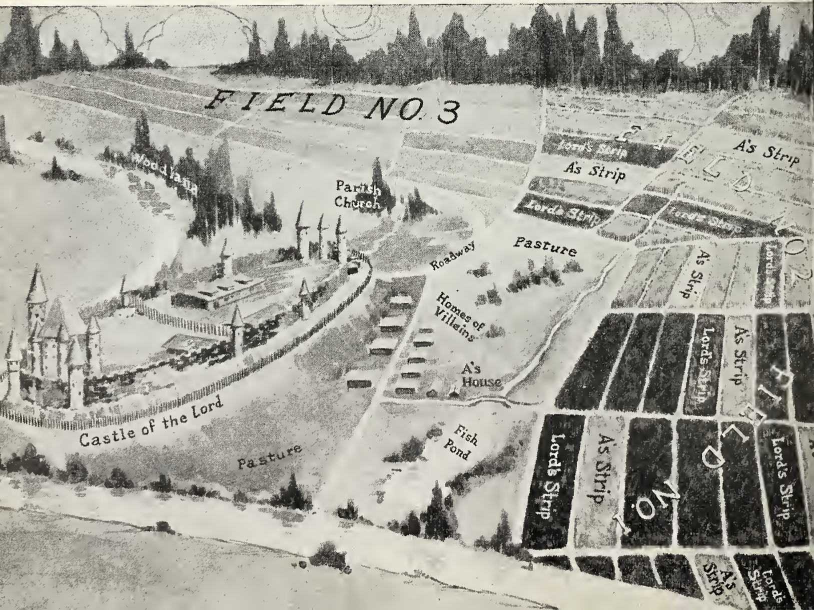
Summer Fallowing. In feudal times farmers realized that it was profitable to rest the soil by leaving it without a crop one year in every three (fig. 21-5). Today many farmers do the same thing by summer fallowing one or more fields each year. On these fields they do not grow a crop, but they cultivate the soil in them frequently. This cultivation lets air and moisture penetrate the soil freely, and helps bacteria to work more efficiently. Cultivation also conserves moisture in the soil by destroying weeds and by keeping a mulch of plant refuse and fine soil on the surface. In some regions in the western provinces the rainfall of one year is not enough to produce a good crop. However, when the farmer summer fallows a field, he prevents the moisture of one year from being used by crops or weeds and saves it in the soil for the next year. This moisture, added to that of the next year, makes a good crop possible.

Rotating Crops. A good farmer tries to keep the soil in a field fertile by using it for different crops from year to year. He may grow a main crop in it one year, a hay crop the second year, and a cultivated crop such as potatoes or corn the third year. This system is known as *crop rotation.* A series of three crops in succession, such as those mentioned above, is known as a *three-year rotation.* The fourth year the farmer starts the same series over again. Fig. 21-6 shows a four-year rotation.

Different crops take plant foods from the soil in different proportions. A hay crop uses much nitrogen to produce stems and leaves; grain crops take much phosphorus to form the kernels; and hoed crops, such as potatoes and sugar beets,

FIG. 21-5. HOW FARMING WAS CONDUCTED IN FEUDAL TIMES.
In the Middle Ages the land was owned by wealthy lords, and was worked by peasants (villeins) who were tenants in their villages. In the "three-field system", two fields, each divided into several long strips of about an acre each, were planted annually. The third field was ploughed, but left to rest instead of being planted. Find in this drawing: the lord's castle; the homes of the villeins; the pasture lands used by all; the unplanted field, field No. 3; the strips cultivated by villein A; the lord's strips cultivated for him by the villeins.

(*Compton's Pictured Encyclopedia*)



remove from the soil a great deal of potassium. Rotating crops, therefore, helps to prevent the soil from losing too much of any one kind of food.

A rotation of grain, hay, pasture, and a hoed crop works well. The grain takes the most plant food from the soil, but it provides feed for stock, or ready cash if it is sold. The hay crop enriches the soil by adding humus to it. This comes from stems and leaves that decay while the crop is growing, also from the sod when it is ploughed under. If the hay crop contains clover or alfalfa, the bacteria on the roots of these add nitrogen to the soil. On hillsides, both the hay crop and the pasture the following year trap water and help to prevent erosion. The hoed crop is kept cultivated and, therefore, enables the farmer to get rid of weeds. Because different crops are attacked by different diseases and insects, crop rotation helps to keep all these pests in check.

Crop rotation has other values. Under this system a farmer has grain on part of his farm, hay on part of it, and hoed crops on another part of it. If one of these crops fail because of weather, insects, or disease, the farmer has the other crops

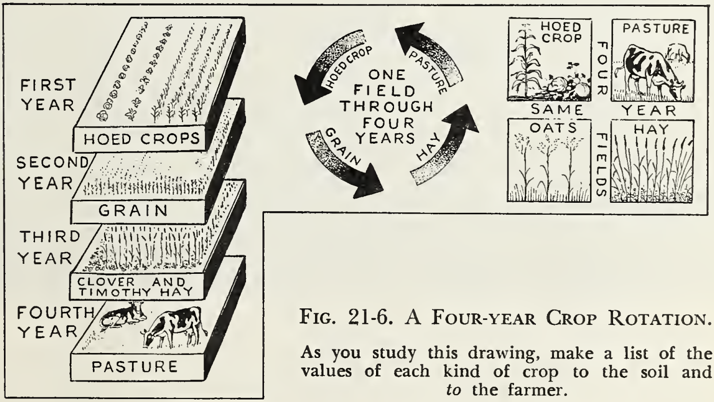


FIG. 21-6. A FOUR-YEAR CROP ROTATION.

As you study this drawing, make a list of the values of each kind of crop to the soil and *to* the farmer.

to provide an income. By planting and harvesting these different crops at different times of the year, the farmer avoids having too much work at any one time of the year.

Now study fig. 21-6 again.

Growing Grass Crops. Pasture and hay crops are good for the soil. Grasses and clovers take from the soil less plant food than grain or hoed crops take. The grass in a thriving sod produces new roots and new blades each year. As the old ones decay, they keep the soil loose and add plant foods to it. Meadows containing clover are particularly good for the soil because the clover roots are the homes of the bacteria that take nitrogen from the air and change it into plant foods.

Grass plants help the soil to absorb rain. By so doing, they prevent erosion by water. Their roots anchor the soil and thus prevent wind erosion. When grass is used for pasture, manure

FIG. 21-7. GROWING PASTURE AND RAISING LIVESTOCK ARE GOOD FOR SOIL.

These Holstein dairy cattle thrive on good clover pasture. Both the cattle and the clover enrich the soil.

is added to the soil by grazing animals, helping to keep it fertile.

Keeping a Good Supply of Organic Matter in the Soil. Farmers must work with nature to keep the soil rich in decaying vegetable matter and humus. New supplies of these are needed to replace the plant foods that are being removed constantly by crops and erosion. Some of these are provided when straw, sod, grain stubble, and other crop refuse are cultivated into the soil. Applying barnyard manure and ploughing under growing crops both add organic matter. Plant refuse and humus in the soil make it easier to cultivate and more capable of holding water. At the same time they reduce erosion and increase the amount of plant food in the soil. See fig. 20-7.

Preventing Erosion Conserves Soil Fertility. Erosion reduces fertility when wind and water remove good topsoil, and when run-off water dissolves and takes away plant foods. In chapter 20 we learned several ways in which farmers can control erosion and thereby help to keep the soil productive.

Raising Livestock. Keeping livestock is one of the best ways for a farmer to keep his fields productive. To feed the stock in summer, the farmer must have pasture fields and meadows — and these improve the soil. In winter the stock is fed grain, hay, and other products of the soil. The animals use only about one-fifth of the plant food in these feeds to make bone, flesh, and milk; the remaining four-fifths goes back to the soil in manure.

Without livestock, the farmer is likely to sell hay and grain and, with these, the plant food in them. This leaves his fields less fertile unless he applies commercial fertilizers.

How Can Farmers Make the Soil More Productive?

To keep the soil as fertile as it has been in the past is not enough. We must make it more fertile. To feed the world's increasing population, every acre of cultivated soil must be made to produce even greater crops and thus more food for livestock and man.

CULTIVATE THE SOIL. The more efficiently the soil is cultivated, the better it is for plant growth, and the bigger the crops it can produce.

Cultivating the land thoroughly provides a layer of fine soil in which seeds germinate well and young plants get a good start in life. Then, as the plants grow, they can penetrate the loosened soil more deeply and reach more plant foods. The water and air needed by all roots can enter and circulate through loose soil more freely. When soil is well cultivated, it retains more water and makes more plant food available to roots. By killing weeds, cultivation saves moisture and minerals for the useful crop.

Cultivation mixes manure, stubble, grass, and other vegetable matter with the soil. Then they decay and make the soil

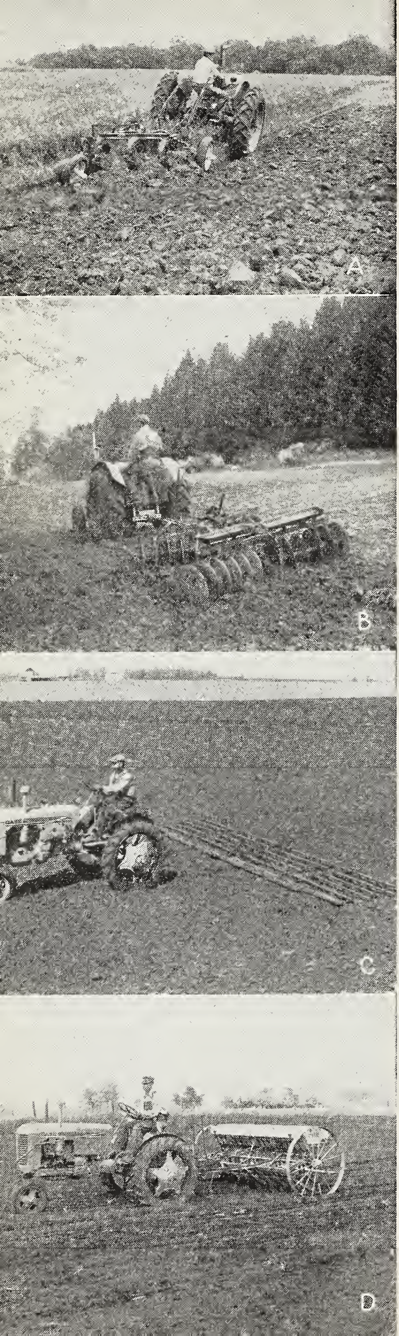


Fig. 21-8. Cultivating and Seeding the Soil.

A, ploughing with a three-furrow tractor plough; B, tractor-drawn discs loosening and turning the soil; C, harrowing to level the soil and to break lumps; D, a seed drill sowing grain and fertilizer.

more fertile. Modern farmers have found that it is better to mix plant remains all through the soil by means of discs and cultivators than to plough them under. In this way they enrich more of the soil and also protect it from erosion. Special kinds of culivators loosen the soil much deeper than ploughs, and improve the land by mixing topsoil and subsoil, thus encouraging roots to grow deeper. Deep cultivation also makes some plant foods that are present only in the subsoil available to roots. The harrow serves three purposes: it levels the soil; it breaks lumps of soil; and it forms a shallow mulch of fine soil which serves as a seed-bed and also reduces the amount of water lost from the soil by evaporation.

FERTILIZE THE SOIL. If we feed the soil, it will feed us. The ancients must have known this, for they applied ashes and manure to their lands. The Indians knew it, too, and so buried a fish in each hill of corn to obtain a better crop.

PUPIL INVESTIGATION. How is soil fertility restored or increased on farms in your community?

> Each pupil try to find answers to the following questions as they apply to some particular farm. How often does the farmer place barnyard manure on each field? For what crop or crops is manure generally applied? Are commercial fertilizers used on the farm? What evidence can you find that the increase in the value of crops grown on fertilized soil is greater than the cost of the fertilizer?

Soils may not be sufficiently fertile to grow crops well. Some of these infertile soils were once productive, but they lost too much plant food through cropping, erosion, and leaching. Other unproductive soils never were rich in plant foods. We can make either of these kinds of soil more productive by increasing the amount of humus in it, by adding to it plant foods not present in sufficiently large quantities, or by both of these methods. The amount of humus may be increased by adding barnyard manure to the soil or by ploughing green crops into it. Other plant foods needed by the soil may be added to it by applying commercial fertilizers.

Barnyard Manure. Manure from livestock is the best fertilizer for soil. It helps to make the soil more productive and, at the same time, improves its condition for cultivation. Because manure contains about four-fifths of the plant foods which were in the feed eaten by the stock, it returns to the soil much of the nitrogen, potassium, and phosphorus that the plants took from the soil. Barnyard manure is even more valuable when some phosphorus fertilizer is added to it.

Manure makes the soil richer in humus. The soil then takes in more water and air, warms up more quickly in spring, and contains more helpful bacteria. Barnyard manure causes sandy soil to hold more moisture, and makes clay soil easier to cultivate.

Good farmers care for, and use, barnyard manure wisely. They store it in sheds or on concrete so that the water from eaves and from rain and snow cannot dissolve plant foods from it and carry them away. To make certain that all the plant foods in the manure get into the soil, farmers spread it thinly on the fields as soon as possible.

Manure is usually cultivated into the soil. There it decays quickly. Sometimes it is spread in thin layers on meadows or on young grain crops to feed the growing plants and, at the same time, to prevent the soil from losing moisture by evaporation.

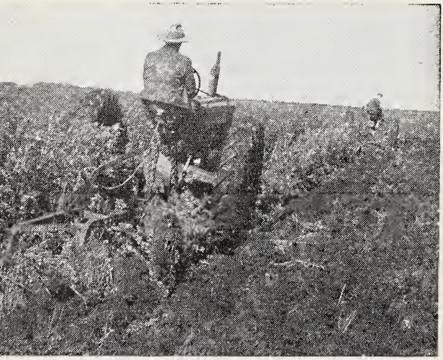


Fig. 21-9. Ploughing Under Legumes for Green Manure.

Green Manure. Green crops ploughed into the soil decay and make it more productive. Plant growth used in this way is called *green manure.*

The decayed remains of green manure give back to the soil the plant foods that the growing plants took from it. They also improve the soil by adding humus to it.

Fast-growing crops such as clover, rye, oats, and rape are usually selected to be used for green manure. Clovers and alfalfa are the most valuable for this purpose because their decayed remains give the soil a great deal of the nitrogen that the bacteria in the nodules on their roots have collected from the air in the soil.

Commercial Fertilizers. In an old barn at Rothamsted, England, a young scientist treated some bones with sulphuric acid, then scattered them in a turnip field. How those turnips grew! That scientist started a new industry, that of making commercial fertilizers for plants.

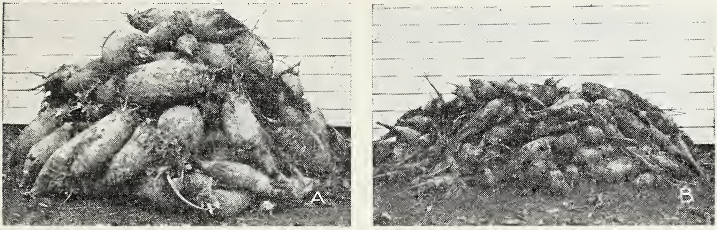
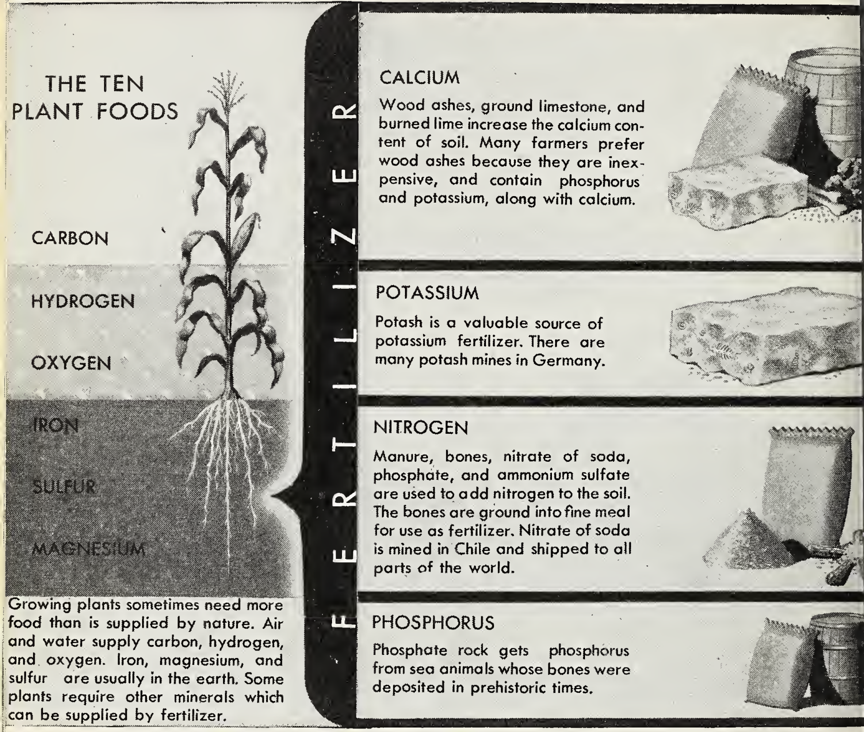


FIG. 21-10. FERTILIZER INCREASES CROP YIELDS.

A, mangels grown in fertilized soil, yielding 28.94 tons per acre; B, mangels grown without fertilizer in similar soil, yielding 2.62 tons per acre. In 30 years of experimenting on the same land, the average yield per acre was almost three times as great on the fertilized area as on the unfertilized area.

The foods most needed by plants, and most likely to be used up in the soil, are nitrogen, potassium, and phosphorus. If crops are to grow well, the soil must provide them with all these plant foods, and must do so in the right amounts. The good farmer finds out whether his soil contains these in the right quantities for the crops he wishes to grow; then he adds to the soil the plant foods that it needs. He does this by applying manure, or commercial fertilizer, or both.

To be certain that the soil will receive all the plant foods it needs, commercial fertilizers are usually prepared to contain nitrogen, potassium, and phosphorus. These are mixed in different proportions for different crops and for different



Growing plants sometimes need more food than is supplied by nature. Air and water supply carbon, hydrogen, and oxygen. Iron, magnesium, and sulfur are usually in the earth. Some plants require other minerals which can be supplied by fertilizer.

CALCIUM

Wood ashes, ground limestone, and burned lime increase the calcium content of soil. Many farmers prefer wood ashes because they are inexpensive, and contain phosphorus and potassium, along with calcium.

POTASSIUM

Potash is a valuable source of potassium fertilizer. There are many potash mines in Germany.

NITROGEN

Manure, bones, nitrate of soda, phosphate, and ammonium sulfate are used to add nitrogen to the soil. The bones are ground into fine meal for use as fertilizer. Nitrate of soda is mined in Chile and shipped to all parts of the world.

PHOSPHORUS

Phosphate rock gets phosphorus from sea animals whose bones were deposited in prehistoric times.

(*From the WORLD BOOK ENCYCLOPEDIA, copyrighted by Field Enterprises, Inc. Reproduced by special permission.*)

Fig. 21-11. Giving Green Plants the Raw Foods They Need.

kinds of soil. If hay, pasture, lettuce, or other leafy crops are to be grown, the fertilizer is supplied with much nitrogen; if grain crops are to be fertilized, more potassium and phosphorus are mixed in to help the plants produce strong stems and plump kernels; for flowers with fine colour, more phosphorus is included; for potatoes and sugar beets, especially on sandy soil, a higher percentage of potassium is likely to be needed. Market gardeners, grain growers, and fruit growers choose commercial fertilizers mixed to meet their special needs.

Commercial fertilizers bear such labels as 2-12-6. A fertilizer labelled in this way contains two per cent nitrogen, twelve per cent phosphorus, and six per cent potassium. The remaining 80 per cent is other material used merely to help to spread the essential plant foods more evenly.

IRRIGATE FERTILE, DRY SOILS. Some soils are fertile, but do not produce good crops because they receive too little rain. These can be made productive by *irrigation.* For centuries irrigation has made farming possible in large areas in Egypt and India. Irrigation has changed the Okanagan Valley in

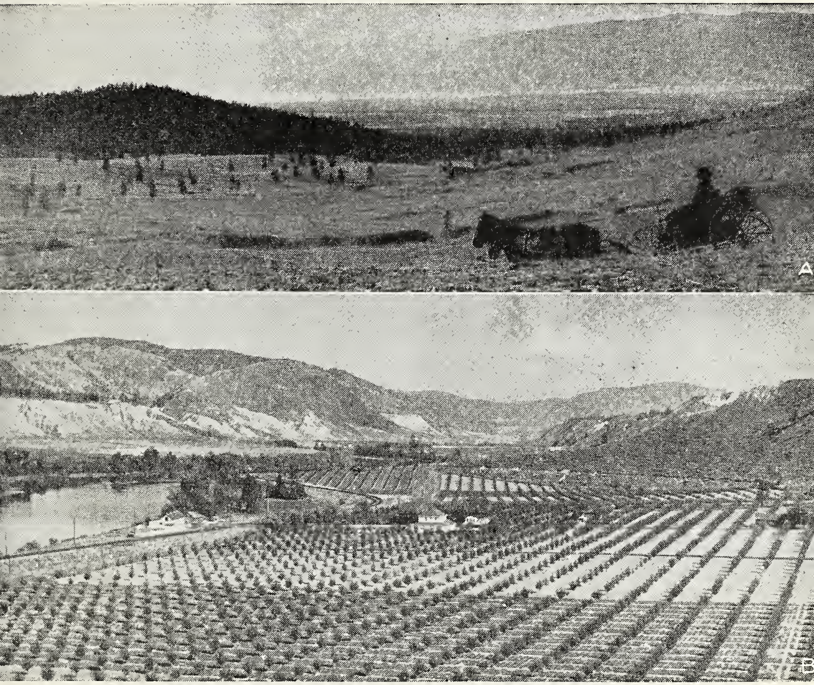


FIG. 21-12. IRRIGATION BROUGHT PROSPERITY.
A, yesterday, a scene of desolate waste in the Okanagan Valley; B, today, thriving young orchards in the same area.

British Columbia from what was desert land in 1900 to one of the world's most famous fruit-growing valleys.

In recent years irrigation has made possible the growth of good crops in the dry foothills of the Rocky Mountains. Here the Bassano Dam (fig. 5-3) has created a reservoir which stores enough water to irrigate thousands of acres of dry and unproductive soil and make possible a thriving sugar-beet industry. The completion of the St. Mary's Irrigation Project on the St. Mary River, in Alberta, is gradually changing another

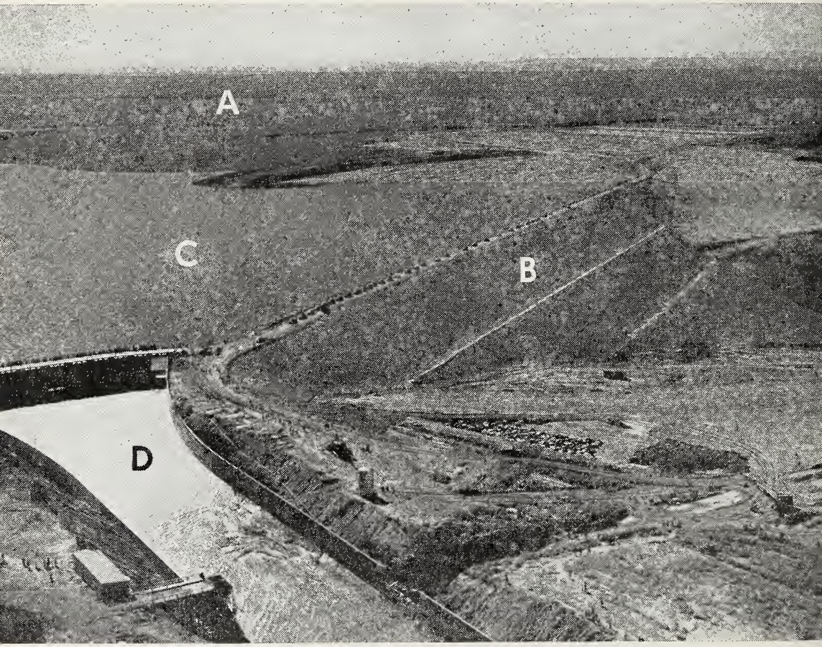


FIG. 21-13. AERIAL VIEW OF ST. MARY DAM ACROSS THE ST. MARY RIVER, ALBERTA.

A, prairie land, within sight of the Rocky Mountains, too dry for crops unless irrigated; B, the huge earth-fill dam half a mile long and 200 feet high, containing 4,000,000 cubic yards of earth; C, the man-made reservoir, covering thousands of acres of land with water; D, the spillway, to carry away water not held for irrigation purposes. When this irrigation project has been all completed, more than 3,000 dust-bowl farmers will have new homes on productive, irrigated land.

area of nearly half a million acres from waste to profitable agricultural land.

Water for irrigation is usually taken from rivers. Across them man builds dams to create lakes, ponds, and reservoirs to store large quantities of water. From these he makes wide channels or ditches, then smaller ditches or mere furrows into the fields. The smallest ditches must be close enough to each other to permit water to penetrate through the soil to all the plants. Through this network the water is permitted to flow to the crops whenever it is needed.

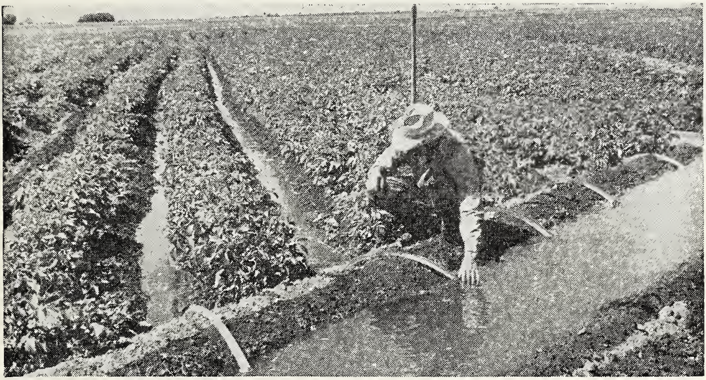


FIG. 21-14. IRRIGATING A CULTIVATED FIELD.
Irrigation is man's way of adding water to soil to make crops grow. The plastic syphons, seen here, take the water from the main irrigation ditch to the spaces between the rows of hoed crop.

By constructing irrigation dams, reservoirs, and channels, man has trapped the water from melting mountain snow and spring rains, has prevented destructive floods, and has changed deserts into productive fields.

Science Helps Farmers Make Their Soil More Productive

Science helps the modern farmer to conserve and improve the fertility of his soil. The provincial and federal governments establish agricultural colleges and experimental farms and stations where scientists spend their lives experimenting to find the best ways of farming — of making soil more productive, of raising crops, of managing livestock, and of controlling insects and diseases harmful on the farm.

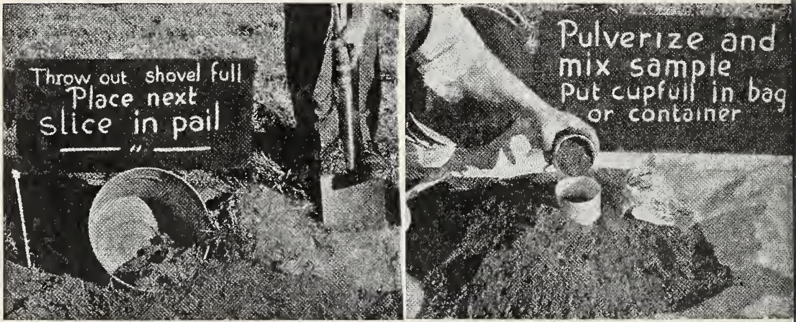


Fig. 21-15. Preparing a Sample of Soil To Be Tested.

When important new information has been discovered by these experiments, it is reported to farmers in various ways. Bulletins and pamphlets are published and distributed free. Motion picture films are made and circulated, farm broadcasts are delivered, and reports are printed in newspapers and agricultural journals. Close to the farmers are the "Agricultural Representatives" who visit farms and explain improved methods of carrying forward Canada's finest industry — Agriculture.

Soil Fertility and Population

Some Problems

1. The United Nations' report of 1951 shows a world population of 2,400 million people, and an annual increase of 25 million people. At this rate, what will be the world's population in 1975?

2. The earth is estimated to have 36 billion acres of land. Six-sevenths of this cannot grow food because it is too cold or too hot, too dry or too wet, too rough or too steep, etc. How many acres can grow crops?

3. Use questions 1 and 2 to find out how many acres there are to produce the food and clothing of each person on the earth.

Canada need not worry about food shortages even if our population has trebled in 50 years. The western prairies produce enough wheat to feed 100 million people. What of other countries where there are fewer acres per person?

Men who should know tell us that it requires 2½ acres of cultivated soil to provide the needs of each person on the earth. Today there are only about two acres of productive soil to each inhabitant. Many people are not fed or clothed as well as they should be. Therefore, more food and clothing must be produced by the soil to meet the needs of the increasing world population. This can be done only if farmers throughout the world conserve and use the soil so well that, as time goes on, it will produce better and bigger crops.

For Discussion

1. Why is soil our most important natural resource?

2. How does each of the following reduce the fertility of a farmer's soil: (a) selling hay; (b) growing oats on the same field for three years; (c) burning straw or stubble; (d) letting weeds grow; (e) wind blowing dust from a cultivated field?

3. Our food cannot contain all the substances needed for good health unless the soil that grows our food plants contains them too.

4. How does each of the following conserve or increase soil fertility: (a) preventing erosion; (b) growing clover; (c) cultivating stubble into the surface soil; (d) cultivating deeply; (e) keeping a large proportion of the land in pasture?

5. The population is more dense in each of the following places than it is in most agricultural areas: The Niagara Peninsula, market garden areas, Denmark, Holland, Belgium, China, and India. For each of these, investigate and discuss the following as possible causes; the soil is very fertile; farming methods are very efficient; the people survive on a small amount of food; the food for many of the people who work at industries other than agriculture is imported.

Things To Do

1. Visit a store where fertilizers are sold. Ask to see different kinds of fertilizers. Find out for what crop or crops each was prepared.

2. Make a class collection of samples of commercial fertilizers. Label each sample with its name and the particular crop for which it is suited.

A Matching Exercise

Rewrite the definitions numbered below and, after each, write the appropriate word or group of words from this list: erosion, mulch, nitrogen, bacteria, strip cropping, nodules, windbreak, legumes, light soil, crop rotation, summer fallow, humus.
Definitions:

(1) Little knobs on the roots of legumes.

(2) Keeping a field without a crop, but cultivated, throughout the summer.

(3) A part of the air in the soil, and changed to plant foods by bacteria.

(4) A row or belt of trees to break the force of wind.

(5) The wearing away of soil by water or wind.

(6) Plants, like clovers and alfalfa, whose roots bear nodules containing bacteria.

(7) Well-decayed organic matter in soil.

(8) Soil so sandy that it is easy to cultivate.

(9) Tiny plants that live in little nodules on the roots of legumes.

(10) Growing hay and a cultivated crop in alternate strips.

(11) A covering of straw, leaves, or other materials to protect the soil from erosion and from loss of water by evaporation.

(12) Changing the crops grown on a field from one year to another.

Review Exercises

1. Make a list of all the things you can find around the house that come directly or indirectly from the soil.

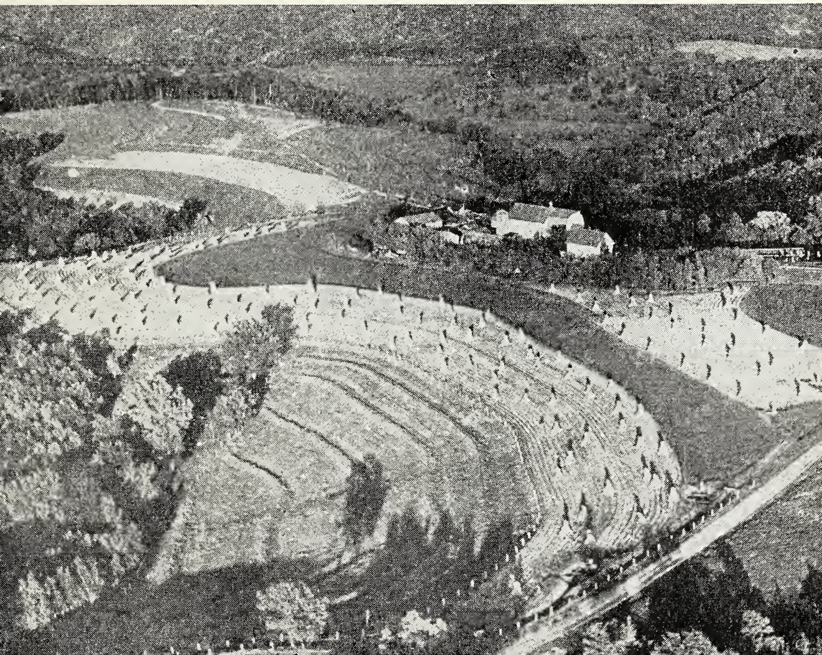
2. Name four important kinds of plant foods that soils need to produce good crops.

3. Make a list of eight ways in which a farmer may make his soil more productive.

FIG. 21-16. GOOD FARMING AND CONSERVATION PRACTICES MADE THIS SCENE POSSIBLE.

Find the following examples of methods used to conserve water and soil, and to produce good crops.

(1) long, winding, alternating strips of grass and corn following the curves on the slopes;
(2) terraces breaking the steeper slope at the lower left into a series of short slopes;
(3) the contour fence below the corn strip;
(4) woodlots on the steepest slopes;
(5) pasture on the more gradual slopes;
(6) the windbreaks around the farm buildings;
(7) wildlife plantations on small areas not suitable for cultivation.



Read

Compton's Pictured Encyclopedia: "Agriculture", Vol. 1, pp. 57-72.

16 mm. Sound Films

Irrigation Farming (SA-9)
Ontario Visual Education Branch.

Land from the Sea (colour)

The Power To Grow (larger and better crops) (colour)

Rebirth of a Farm

Science Helps the Farmer (colour)
National Film Board, Ottawa.

Film Strips

Farmers of Tomorrow
United Kingdom Information Office, Ottawa.

UNIT EIGHT

Keeping Our Home and School Surroundings Useful and Attractive

22. *LET'S MAKE A VEGETABLE GARDEN*

Through planning and preparing to make a vegetable garden, we shall learn about the nature of seeds, see plants develop from them, and discover the conditions necessary for their germination and growth. Then we should enjoy starting plants indoors or in a hotbed, sowing seeds outdoors, caring for our own vegetable garden, and experimenting with seeds and fertilizers.

23. *LET'S MAKE OUR SURROUNDINGS BEAUTIFUL*

Every school and home looks more beautiful when surrounded by well-kept lawns, attractive trees and shrubs, and colourful borders of perennial and annual flowering plants. This chapter will guide us as we plan and carry out such improvements—select and obtain the plants we wish, plant and care for them, and learn how to make a good lawn. Although we may not become landscape gardeners, the work will be fun and the results will give pleasure to all who see them.

22

LET'S MAKE A VEGETABLE GARDEN

A VEGETABLE GARDEN at school or at home has several values. From it we obtain foods rich in vitamins and minerals, and essential in our daily diet. While planning, planting, and caring for a vegetable garden, we learn much about plant life and soils. Then, too, gardening can be fun. Let's have a vegetable garden!

Planning the Vegetable Garden

First we must decide what kinds of vegetables we wish to have, and the approximate quantity of each. Then we will need to find out the conditions required for each kind to grow, how it is grown, and how much seed to buy.

Helpful information may be obtained from books on gardening, from seed catalogues, and from bulletins supplied by Provincial and Federal Departments of Agriculture. It is advisable to write early for these. We should also ask our parents, the neighbours, and market gardeners for help, then report to class what we learn from them.

CHOOSING THE PLACE FOR A VEGETABLE GARDEN. The vegetable garden should be made where growing conditions are favourable. The topsoil should be mellow, at least six to eight inches deep, free from stones or other rubbish, level enough to prevent erosion, and well drained. A sandy soil or sandy loam dries and warms up soon enough in spring to make early crops possible. Vegetables need full sunlight. The vegetable garden, therefore, should not be close to trees or buildings. Trees take from the soil too much of the water and plant food needed by the vegetables.

CHOOSING THE VEGETABLES. Small gardens usually include tomatoes, beans, beets, lettuce, radishes, carrots, and onions. In larger gardens cabbages, cucumbers, squash, corn, peas, and potatoes may be grown. Such perennials as rhubarb, currants, and various kinds of berries may also be included.

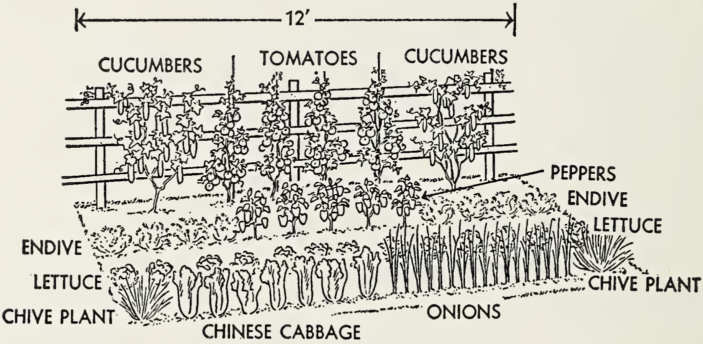


Fig. 22-1. A Garden for Salad Vegetables.

A vegetable garden can be both useful and attractive. Early radishes may be grown between the tomato plants. Cabbages may be planted after the lettuce is used.

The time of planting different vegetables varies with their hardiness and the length of their period of growth. The seeds of vegetables such as carrots, lettuce, peas, radishes, and onions may be sown early because they produce young plants which can withstand frost or which will not appear above ground until that danger is past. Beans and tomatoes must not be planted till later. Cabbages and turnips may continue to grow long after the first autumn frosts have killed corn and tomatoes. Radish and lettuce seeds should be sown at intervals because the plants mature in as short a time as three weeks.

Such late vegetables as carrots, beets, turnips, and late cabbages may be planted after early crops have been harvested, or in rows alternating with early vegetables as lettuce, beets, and peas. Sometimes the seeds of such late vegetables are planted in the same row as those of lettuce or radishes, or in a separate row an inch or so away, then left to mature after the others have been harvested.

A Planting Table for Vegetables

NOTES:

1. A. – April; M. – May; J. – June; Jy. – July; S – September.

2. In the last column of the table, W indicates that the crop occupies the ground for the whole season, E that the crop is early enough to be followed by others, and L that the crop is late, and may follow others.

Name	Seeds or Plants per 100-foot Row	Time To Plant	Depth To Plant	Distance between Rows	Distance between Plants in Row	Crop Times
Beans	1 lb.	M. Jy.	1½″-2″	2′	4″-6″	W
Beets	2 ozs.	M. Jy.	½″	1′-1⅓′	2″-3″	E, L
Early Cabbage	¼ oz.	A. M.	¼″-½″	1½′-2½′	1½′-2′	E
Carrot	½ oz.	A. M. J.	¼″-½″	16″	2″-3″	W, L
Sweet Corn	2 ozs.	M. J.	2″	2′-2½′	8″-12″	W, L
Leaf Lettuce	¼ oz.	A. M. J.	¼″	1′-1½′	4″-6″	E
Onion Sets	2 qts.	A. M.	1″-1½″	1′-1½′	1″	W
Parsley	¼ oz.	A. M.	¼″	1′-1½′	2″-4″	W
Parsnip	1 oz.	A. M.	½″-1″	1½′-2′	3″-4″	W
Peas	1 lb.	A. M.	2″-3″	2′	½″-1″	E
Potato	10 lbs.	A. M.	4″	2′-2½′	9″-15″	W
Radish	1 oz.	A. S.	½″	6″-12″	½″-1″	E
Tomato Plants	25-50	J	3″-4″	3′-4′ (staked 16″)	3′-4′	W, L

DRAWING THE PLAN. A plan should always be made before planting a garden. This should be drawn to scale to show the size of the garden plot, the directions of the rows, what

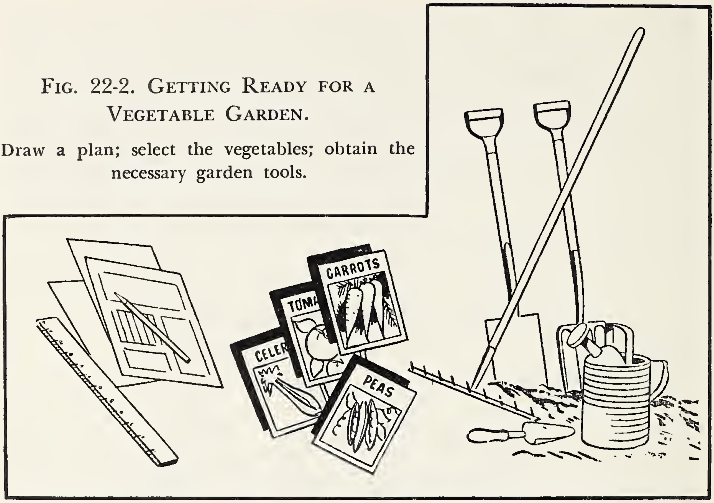


Fig. 22-2. Getting Ready for a Vegetable Garden.

Draw a plan; select the vegetables; obtain the necessary garden tools.

vegetable is to be grown in each row or part of a row, and the distances between the rows.

The rows for small-growing vegetables such as beets, carrots, lettuce, and radishes may be as little as one foot apart. Rows of cabbages, sweet corn, and tomatoes should be spaced much farther apart. If rows are planned to run north and south, they will shade each other less. For the same reason, tall plants should be in the north part of the plot.

PREPARING THE SOIL. Garden soil must be thoroughly cultivated if it is to grow good crops. Deep cultivation, eight or nine inches down, makes the soil loose and airy. Finely pulverized soil is necessary for a good seedbed. Fall cultivation helps the frost to improve the soil and makes it dry up earlier in spring. Soil should never be worked until it is dry enough to crumble easily after a handful has been pressed tightly. Permanent harm can be done to soil by working it when it is too wet.

Garden soil can be improved. The addition of barnyard manure or decaying vegetable matter builds humus in the soil. This makes clay soil looser, more airy, better able to take in water and air, warmer, and more easily cultivated. It makes all kinds of garden soil richer in plant foods and able to hold more water.

Commercial fertilizers, carefully chosen, help soils to grow better vegetables. We may send samples of garden soil to the nearest agricultural college or experimental station to be tested chemically. The tests will show what plant foods are in the soil, and how much of each. The official can then advise what plant foods should be added to the soil for the particular plants we wish to grow, and what kind of fertilizer will supply these plant foods.

It is important to have the right amount of water in the soil. Good drainage by nature or by man, is essential to garden soil. Irrigation, from trenches or from sprinklers, makes dry but fertile soil productive.

Learning About Seeds and Seedlings

HOW DO SEEDS PRODUCE YOUNG PLANTS? We marvel at many of the works of Nature. When a tiny, hard, dry, apparently lifeless seed becomes a living, growing, green plant, we may well stop and wonder how this miracle can take place. Let us watch it happen, then try to find out how Nature has planned her miracle.

EXPERIMENT 22-1. How do bean seeds produce young plants.

Plant some beans about one inch deep in soil, sand, or sawdust. Keep them moist and in a warm place. Each day dig up a seedling and draw it as you see it, dating the drawing. After 10 days compare your drawings with those in figure 22-3 and add labels to them. What purpose was served by the arch? Why did its growth not pull up the root instead of the seed leaves? When did you first see the little bud which later became the true leaves and stem? What protection did the seed leaves give before they were pulled out of the ground? What did their green colour, formed later, enable them to do for the plant? Why did they finally shrivel up?

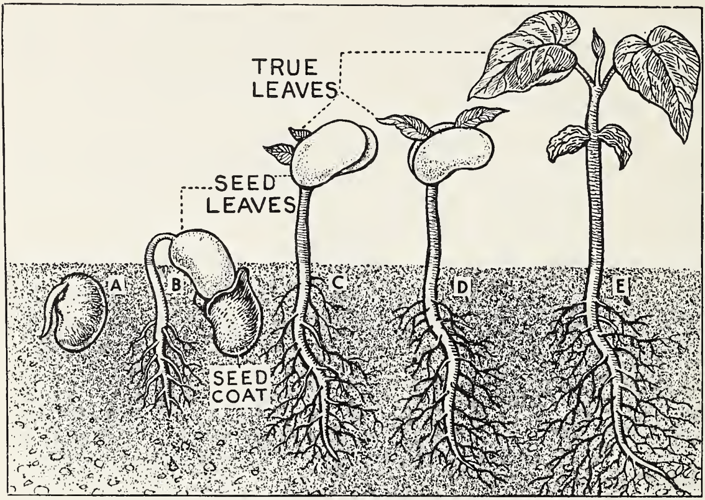


Fig. 22-3. Stages in the Growth of a Young Bean Plant. A, the seed sending out a root; B, the rootlets, anchoring the growing plant while the stem lengthens and lifts the seed leaves from the seed coat; C, D, and E, the true leaves developing while the root system and stem elongate.

When a seed produces a young plant, we say it *germinates.* As the bean seed germinates, it sends two thick *seed leaves* up to the surface, and a little root downwards. The two seed leaves become green for a while, make a little food, then shrivel and die. In the meantime, tiny new leaves and a growing stem emerge from between the two seed leaves. The new growth becomes the branched stem and leaves of the mature bean plant.

EXPERIMENT 22-2. How do kernels of corn produce corn plants?

Repeat experiment 22-1, planting kernels of corn. Make a series of dated drawings of the stages of growth of a young corn plant. Label: root, root branches, curled leaves, open leaves. See fig. 2-3.

When a corn seed garminates, it sends several roots downwards into the soil. At the same time it sends a shoot, consisting of stem and leaves, up into the air.

HOW ARE SEEDS READY TO GERMINATE? Nature has prepared seeds well for their work of producing new plants. Some experiments will show how.

EXPERIMENT 22-3. How is a bean seed fitted to produce the root, stem, and leaves of the young bean plant?

> Soak some bean seeds over night. Remove the tough outer skin from one of these. Notice the little pointer-like part which becomes a root. Separate the two halves of the bean. These are the seed leaves that came to the surface and turned green, but soon died. Find two tiny folded leaves attached to the seed leaves and the "root". Try to unfold one and find its little veins. As these leaves grow, a stem develops with them and produces more new leaves.

This experiment shows that a bean seed contains a little plant with root, tiny leaves, stem, and two temporary seed leaves, all protected by a tough outer skin. Likewise, a seed of any other plant contains a tiny plant, called an *embryo,* and a supply of stored food to nourish the embryo as it grows. In these ways seeds are ready to germinate.

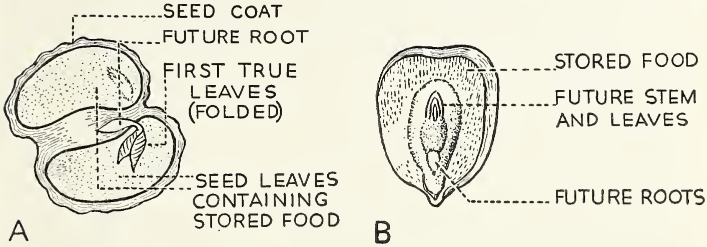


FIG. 22-4. SEEDS ARE WELL PREPARED TO GERMINATE. A, a soaked bean seed laid open; B, a soaked corn seed beginning to germinate.

EXPERIMENT 22-4. What food in a bean seed enables the little plant to start growing?

> Separate the parts of another soaked bean seed. Dip these parts into a solution of iodine. Which parts turn blue? What plant food is indicated by the blue colour?

The blue colour, produced in the presence of iodine, shows that the seed leaves of the bean contain stored starch. As the seed leaves give this up to feed the young plant, they wrinkle, then fall from the plant. In the meantime the new green leaves become big enough to make the food needed by the plant for growth.

A seed is a neat, well-protected package containing a young plant and a supply of stored food.

WHAT CONDITIONS ARE NECESSARY FOR SEEDS TO GERMINATE?

EXPERIMENT 22-5. What temperature is best for seed germination?

Soak seeds of corn, beans, radishes, or wheat for half a day. Plant them in sawdust or in soil in three glass tumblers, with the seeds at a depth of about half an inch, and close to the glass. Place one tumbler in a warm room (fig. 22-5, A), one in a very cold place (fig. 22-5, C), and one in a cool hall or cellar. Keep all moist, with no free water, for several days. Make sketches to show the amount of growth by the seeds in each place.

Seeds germinate best at room temperature. For this reason it is useless to sow seeds outdoors until the soil becomes quite warm. Corn seeds require warmer soil than grain, and so are planted later.

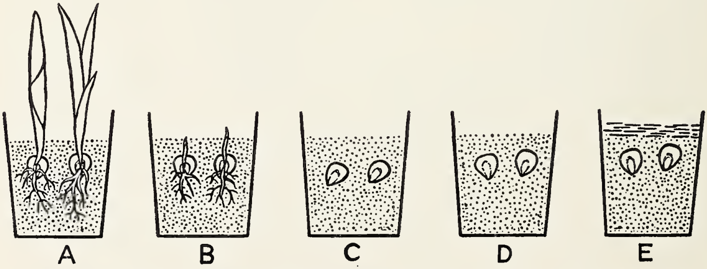


Fig. 22-5. Seeds Need Warmth, Moisture, and Air To Germinate.

A, corn seeds germinating when kept warm, moist, and exposed to air; B, cool, moist, and exposed to air; C, cold, moist, and exposed to air; D, warm, dry, and exposed to air; E, warm, covered with water (keeping air out). What required condition was lacking in B? C? D? E?

EXPERIMENT 22-6. What amount of moisture is best for seeds to germinate?

Arrange experiments as above, with seeds in three tumblers of sawdust: one kept moist, but with no free water; another kept dry; and the third with the seeds covered with water. Keep all warm and exposed to air. Make drawings to show the amount of growth in each after a week. Compare your observations with those shown in fig. 22-5, D.

Seeds require moisture to germinate. If planted in a dry garden or field, they will rest until it rains, then start to grow immediately.

EXPERIMENT 22-7. What effect has air upon the germination of seeds and the growth of young plants?

Place damp soil or sawdust in each of three bottles or sealers. Leave the first vessel one-quarter full; the second, one-half full; and the third, three-quarters full. Plant soaked seeds in each container. Cork each container and leave it in a warm place for a week. Compare growths. How did the amount of growth compare with the amount of air in the bottle?

Seeds need air to germinate and start growing. They use the oxygen in the air to breathe. Loosely cultivated soil permits air to reach newly planted seeds. When seeds are covered with water, as in experiment 22-6, they cannot get enough air to germinate, so they die and decay. Similarly, seeds in a part of a field covered with water fail to germinate, and soon decay, both because of lack of air.

Seeds do not need light or soil to germinate.

Starting the Vegetable Plants

Many vegetable plants are too tender to be grown outdoors before all danger of frost is past. If the seeds are not sown until then, the vegetables will not be large enough to be used until late in the season. For this reason, we usually plant the seeds of cabbages, tomatoes, and cauliflowers indoors, or in a hotbed, or in a greenhouse. When the plants are large enough, and all danger of frost is past, we transplant them to the garden.

STARTING PLANTS INDOORS. A good soil mixture for starting seedlings indoors consists of two parts of good garden loam, one part of well-pulverized decayed manure or compost, and one part of coarse sand.

Seeds may be sown in shallow boxes called flats, in flower pots, or in shallow pans. The container must have drainage holes in the bottom.

Start Some Vegetable Plants Indoors

1. *Sow the Seeds.* Select a container. In it place a layer of broken pottery or other drainage material. Nearly fill the vessel with well-prepared soil, sifted to remove stones and rubbish. Level and press the soil with a piece of board.

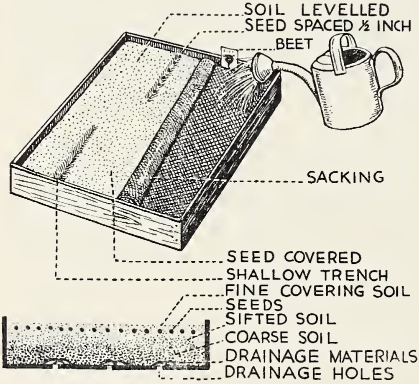


FIG. 22-6. SOWING GARDEN SEEDS INDOORS.

Make shallow trenches about an inch apart for the seeds. Sow the seeds about half an inch apart in these. Cover them with soil to about twice their thickness. Press the soil firmly with a piece of board.

Water the soil thoroughly by placing the container in a vessel of water until all surface soil appears damp, or by covering the soil with sacking and sprinkling water on it until some drains through the holes in the bottom.

2. *Care for the Seedlings.* Put the container in a warm place. Cover the surface of the soil with paper until the seedlings come up. Water the soil as you did at first whenever its surface appears dry.

When green leaves appear, remove the covering paper. Keep the soil merely moist. Turn the container around each day so that the young plants will not grow too much in one direction – towards the light.

3. *Transplant the Seedlings.* When the seedlings are about two inches high, transplant them into containers in which they will

have more room to grow. The soil for this purpose should contain less sand. Be sure the young plants are watered thoroughly as soon as they are transplanted. Keep the soil moist and the containers in good light. When danger of frost is past, transplant the seedlings into the garden.

STARTING PLANTS IN HOTBEDS OR COLDFRAMES. Market gardeners start many of their vegetables in hotbeds. These are like low, small, temporary greenhouses. Fig. 22-7 shows how a hotbed is set up. The wooden or concrete sides and sloping glass tops protect the tender seedlings within from winds, cold, and sudden changes in temperature. The layer of fresh horse manure produces heat as it decays. This warms the soil above it, close to the roots. The sun shining through the glass warms the soil and air during the day. At night the glass keeps the heat in. If good soil is used in the hotbed, and the little garden within is kept moist and ventilated, the young plants will grow rapidly. Radishes and lettuce may be used from the hotbed. Tomato and cabbage plants started in it may be transplanted elsewhere when danger of frost is past.

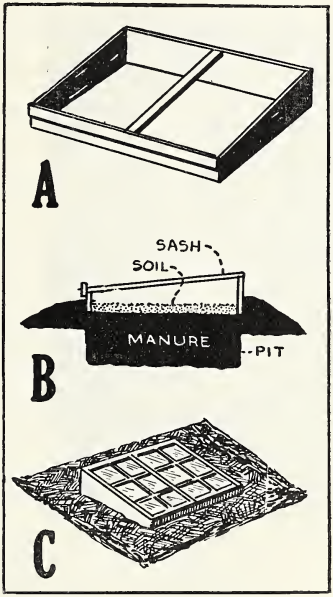


FIG. 22-7. PREPARING A HOTBED.

A, the frame, made to fit the glass sash; B, the pit dug, manure filled in, frame put in place, and soil prepared for seeds; C, the hotbed in use.

Electric hotbeds are heated by lead-covered electric wires. These wires are laid in parallel rows under the layer of soil in which the seedlings are grown. The soil is kept at the right temperature by a thermostat which turns the electric current on and off as required.

Coldframes are like hotbeds, but are heated only by the sun. They are used for starting seedlings in late spring and for hardening plants from hotbeds before they are transplanted into the garden.

SOWING VEGETABLE SEEDS OUTDOORS. The seeds of carrots, beets, radishes, lettuce, peas, and beans are usually sown directly in the garden soil where the plants are to grow. The soil is first thoroughly cultivated and raked to give a level seed-bed of finely pulverized soil.

Sow Some Vegetable Seeds in Your Garden. Use stakes and twine to make straight rows according to the plan drawn earlier. Make a shallow trench under the twine with a trowel or a sharp stick. Sow the seeds in this about half an inch apart. Very fine seeds are scattered more evenly if they are first mixed with fine sand. Sow small seeds half an inch or less in depth, and larger seeds, such as beans and peas, a little more than an inch deep. Press the soil over the seeds with a board, rake, or hoe. If the soil is moist, do not water it after sowing the seeds; if it is dry, soak it with a fine spray.

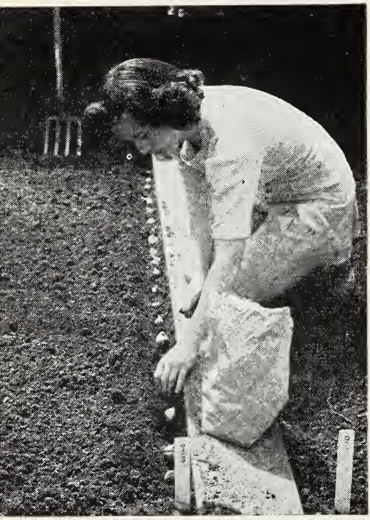


FIG. 22-8. GARDENING CAN BE FUN.

Notice the well-cultivated soil, the marking stakes, the shallow planting trench, the board to assist in making a straight row, and the care with which the girl is spacing and placing the Dutch set onions.

TRANSPLANTING VEGETABLE PLANTS. The best time to transplant plants is in late afternoon or on a cool, cloudy day. Then they should not wilt.

Transplant Your Vegetable Seedlings from Indoors. Mark the rows, then the place where each plant is to grow. Now dig the holes. Lift each plant separately from the container in which it is growing, making certain that a lump of soil remains attached to its root. Plant it immediately at the depth to which it had previously grown.

Fill around its roots with good soil, then press this firmly. Fill the depression around the plant with water, then with loose soil when the water has soaked away.

Caring for the Vegetable Garden

THINNING, WEEDING, AND CULTIVATING VEGETABLES. Each good seed produces a plant, and each plant requires more and more space as it grows. If we overlook this in planting seeds, we must later remove some of the plants to give the others sufficient space to grow well. We call this *thinning*. The table on page 385 shows how far apart the plants of each vegetable should be when we have thinned them.

Weeds steal moisture and plant foods from the soil, leaving less for vegetables. Therefore, we must keep the weeds hoed out or pulled.

For vegetables to grow well, the surface layer of soil around them should be kept loose and fine. When cultivating the soil for this purpose, we must be careful not to injure the roots of plants. The soil should be cultivated as soon as it is dry enough after being watered by rain or garden hose. Regular and thorough cultivation destroys weeds and helps the soil to retain water.

KEEPING THE VEGETABLE GARDEN FREE FROM INJURIOUS INSECTS. Each kind of vegetable has its own insect enemies. Some insects harm plants by eating their leaves or stems. Their foliage then makes insufficient plant food for the vegetable to continue growing well. Other insects suck juices from plants, thus stealing plant food that has already been made by the leaves. Various kinds of sprays and dusting powders can be bought to suffocate or poison garden insects. Fig. 22-9 and the table below give information which helps us to recognize common injurious insects, and to know how to control them. More complete directions will be found on the containers in which the sprays or dusts are sold.

Insect Enemies in the Vegetable Garden

Vegetable	Insect	Damage to Plant	Method of Control
Asparagus	asparagus beetle	eats leaves and stems	handpick daily
Cabbage and Cauliflower	cabbage worm	eats pieces from foliage	dust with poison when leaves are damp
	cutworm	cuts off plant at the ground	place a paper collar or poisoned bran mash around the base of the plant
Cucumber	cucumber beetle	eats foliage and roots	handpick or use poison dust
Squash	squash bug	sucks juices from plant	handpick or use poison dust
Onion	onion maggot	feeds in roots and bulbs, causing rot	place DDT in the soil around the plant
Potato	Colorado potato beetle	eats foliage	handpick if few; apply poison sprays or dust
Radish	raddish maggot	burrows in the roots	put DDT in the soil around the plants
Tomato	tomato worm	eats foliage	handpick
Corn	corn borer	eats burrows in stems and ears	destroy all affected parts and plant refuse
	corn ear worm	eats ears	destroy affected parts and plant refuse

EXPERIMENTING WITH FERTILIZERS. The garden is a good place in which to find out how useful commercial fertilizers are, and which ones are best. Carry out some of these investigations.

PUPIL INVESTIGATIONS

1. *How do commercial fertilizers affect the growth of vegetables?* Obtain some commercial fertilizer recommended for vegetables. Sow half a row of vegetables without fertilizer. To the other half row apply fertilizer according to the directions obtained with it. From week to week compare the growth of the vegetables in the two half rows.

2. *What kinds of fertilizers are best for vegetables?* Obtain samples of several kinds of commercial fertilizers. Apply them

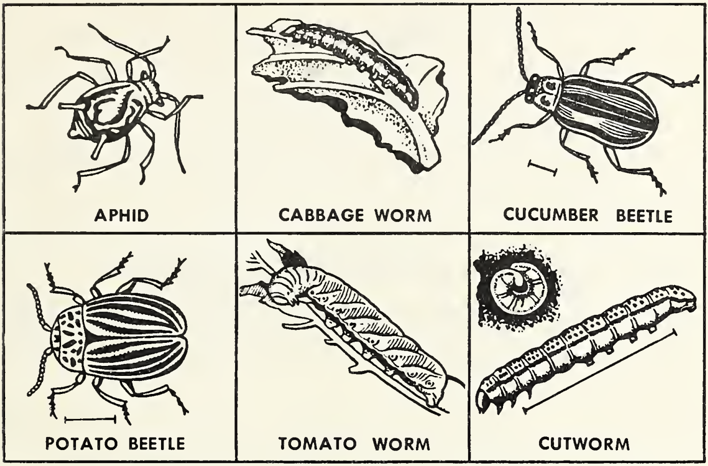


FIG. 22-9. SOME INSECTS INJURIOUS TO VEGETABLES.

according to directions to different parts of the garden and to different kinds of plants. Judge from the growth of the plants which fertilizer is best for that soil and for those particular vegetables.

SUMMER CARE OF THE GARDEN. It is much better not to have a garden than to let it become unsightly through the growth of weeds. This is particularly true of school gardens. Some plans must, therefore, be made to see that the garden is regularly weeded and cultivated throughout the summer months. Pupils may take turns at cultivating the school garden. If this cannot be arranged, the trustees should hire someone to do this work.

Review Exercises

1. Re-write or re-number the following statements in correct order to show the stages in the germination of a bean seed.

(1) The two halves of the bean turn upwards, separate, and become temporary leaves.

(2) The seed leaves shrivel and fall off.

(3) Branches form on the main root.

(4) The seed absorbs water.

(5) A bud, then little leaves, grow out from where the seed leaves are joined.

(6) A little pointer-like growth comes out of the seed and grows downwards as the beginning of the root.

(7) The two halves (seed leaves) of the bean seed become green and make food for a while.

(8) The seed gets bigger and splits its coat.

2. Make a list of statements such as those above to show the right sequence of changes when a corn seed germinates.

3. Re-arrange the following names of types of soil in the correct order of suitability for growing vegetables: clay soil, sandy loam, sand, clay loam, loam.

Test Questions

1. What conditions are necessary for seeds to germinate?
2. What is a seed?
3. What benefits are obtained by cultivating the soil of a garden?
4. In what two main ways does a coldframe differ from a hotbed?

◆

Film Strips

Preparing and Planting Gardens (colour) (with manual)
Ryerson Film Service, Toronto.

23

LET'S MAKE OUR SURROUNDINGS BEAUTIFUL

SPRINGTIME means warmer days, longer hours of sunshine, opening buds, and green grass. All of these make us think of the outdoors, of the grounds around home and school, of trees and shrubs and opening flowers, and of how these make our surroundings more attractive and enjoyable.

Planning Attractive Gardens

You will remember the interesting times we had in autumn (chapter 4) planning ways of making our surroundings at

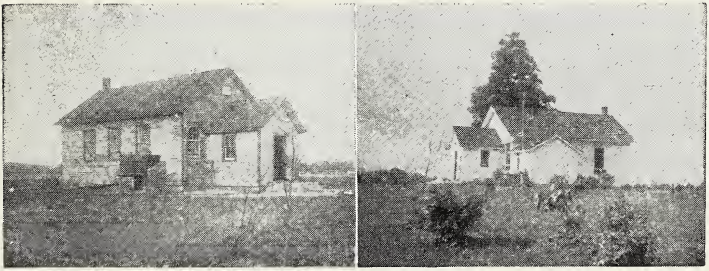


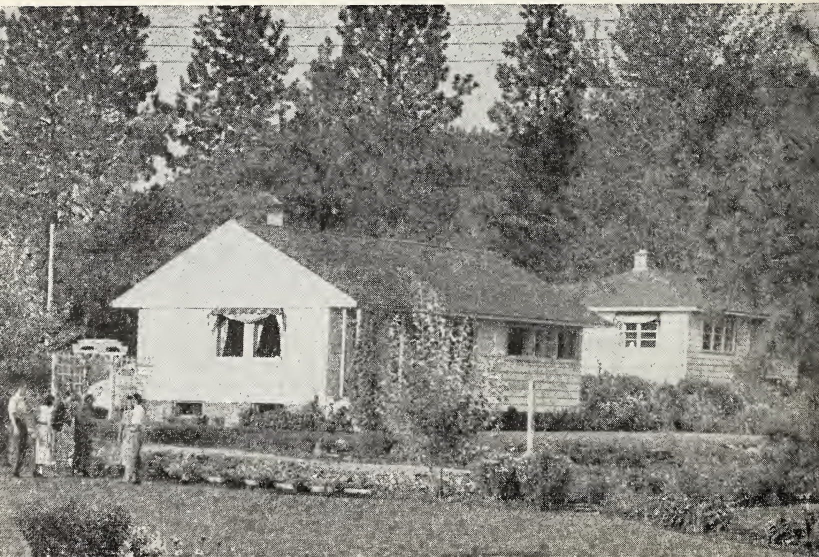
FIG. 23-1. A RURAL SCHOOL — BEFORE AND AFTER BEAUTIFICATION. This rural school, S.S. No. 2 Crowland, near Welland, Ontario, won the Provincial School Ground Improvement Competition in 1948. The work included repairs, a clean-up, painting, grading and seeding the ground, and planting shrubs and flowering plants.

home and at school more beautiful. We visited other schools and homes and talked with experienced gardeners to get ideas. After we had discussed how we would like our surroundings to look, we drew a plan to scale to show the new arrangements of lawns, walks, flower beds, playgrounds, and planting of trees and shrubs. Now it is time to start again where we left off.

COMPLETING OUR PLANS STARTED IN AUTUMN. We should review our autumn plans in early spring so that we will be ready to carry them out as soon as weather permits. New ideas may make us want to change our old plans. Of course we should write early to seed houses and nurseries for their new catalogues.

Some planning can be done only in spring. If any trees, shrubs, or perennials around the home or school have been winter-killed, we must decide what plants will replace them best, and find out where to get these. An inspection of the lawn will show whether parts of it need improving. Perhaps

FIG. 23-2. ATTRACTIVE HOME GROUNDS.
Trees, shrubs, flowering borders, interesting pathways, well-kept lawns, and an attractive arbour make this outdoor living room beautiful.



the lawn mower or some other garden tools or implements should be repaired or replaced. All these things should get early attention.

LET'S MAKE A PLAN FOR HOME GROUNDS. In autumn we made plans for the improvement of our school grounds. Now let us review what we learned then by drawing up plans for the improvement of our home surroundings.

Attractive home grounds usually have a front and a back lawn, a foundation planting of shrubs around the house wherever there is space, some shrubs as a background around the edges of the back yard, and some flowering plants. The surroundings of almost any home can be made beautiful without too much expense or labour.

Make a plan, drawn to scale, for your home grounds. It will be necessary to make a large drawing of your whole lot, showing the dimensions to scale, and all buildings, walks, and trees in the right places. You will get ideas for your planning by visiting attractive grounds, or by studying pictures of well-designed home surroundings. Now you can decide where

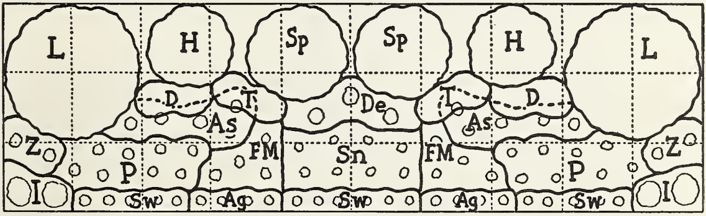


FIG. 23-3. A BORDER OF SHRUBS, PERENNIALS, AND ANNUALS.

This plan has been drawn to scale for a border 20′ x 6′. Each square is 2′ x 2′. All plants are shown, correctly spaced; they should not be planted closer to each other. Plants for different colours, heights, and seasons of bloom have been included. The asters, growing after the flowering bulbs die down, are shown overlapping the bulbs.

Shrubs: L, lilac; Sp. spirea (white); H, hydrangea (autumn). *Perennials:* De, delphinium; T, tulips; D, daffodils; I, iris. *Annuals:* As, asters (mixed); Sn, snapdragons (mixed); FM, French marigold; P, petunias (mixed); Z, zinnia (large); Sw, sweet alyssum (white); Ag. ageratum (blue).

shrubs will look well, but will not shade windows or be in the way of paths. Mark these places on your drawing. You may wish to sketch in a border around the back yard for shrubs and perennial flowering plants. This should be narrow enough to leave a good-sized lawn, but wide enough for shrubs to grow to full size. Three feet is about the narrowest a border can be to look well. Its edges may be straight or gently curved. You may want to add to your plan a rose bed, flower borders an arbour covered with climbing vines, or a hedge.

SELECTING PLANTS FOR SCHOOL AND HOME BEAUTIFICATION. In autumn we decided where to make the lawn, where we should plant shrubs and perennial flowering plants, and where beds of showy annual plants would look best. Then we prepared these areas to give our plants a good start in spring. Now we must decide what plants we will put in each place.

We should choose the plants wisely for each place in our plan. Successful gardeners, and men who manage nurseries, will be glad to tell us what trees, shrubs, or small flowering plants will look best in each part of our grounds. We can get other ideas by studying coloured pictures and descriptions of trees and shrubs and of perennial and annual flowering plants in catalogues and magazines.

Trees and Shrubs. Trees and shrubs combine well with other flowering plants to make grounds attractive. Trees form a setting for buildings, and a good border around large grounds. Their shade is welcome, too. Sugar maple, Norway maple, and elm are good for school grounds.

Shrubs blend well with trees, flowers, and the lawn. They improve the appearance of a building when planted around its corners and along its sides. The shrubs at the corners should be tallest; those between the windows, of medium height; and those under windows and close to flower borders, low. No shrub should be planted closer than two feet from a building. Shrubs along boundary fences make an attractive background for perennials, annuals, and the lawn. Usually they look best in clumps, but some are more attractive growing alone. They should always be planted far enough apart to grow to full size without crowding each other.

Only those shrubs that will grow well in the locality should be selected. We will enjoy them more if they show variety in colour of foliage and flowers, and if they give some bloom all through the growing season.

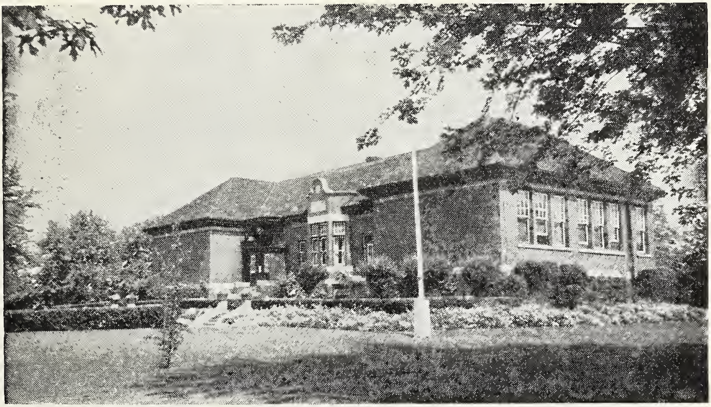


FIG. 23-4. ATTRACTIVE SCHOOL SURROUNDINGS.

The beautiful grounds of this school, S.S. No. 15, Nelson, near Burlington, Ontario, are a tribute to the teachers, the pupils, the trustees, and the caretaker. The trees, shrubs, flower beds, rockeries, and lawn are a challenge to all who see them to try to make their own schools and homes as attractive.

PUPIL INVESTIGATION. Make a survey of trees, shrubs, and flowering plants in your locality.

Visit parks and beautiful gardens at homes and at other schools. Find out what trees are grown most commonly for beauty and shade. Make a list of shrubs that are tall, of medium height, and low. Get the name of at least one spring-flowering shrub, one summer-flowering shrub, and one shrub that blooms in autumn. Make a list of shrubs that provide variety in colour of both foliage and flowers.

Shrubs for Eastern Canada

Time of Bloom	Name	Colour of Flowers	Height	Special Characteristics
April-May	golden bell (forsythia)	bright yellow	5′ - 6′	twigs will blossom indoors in winter; too tender for the North.
May	lilac	various	4′ - 10′	for corners; needs a bright place
May-June	bridal wreath (spirea)	white	4′ - 6′	blooms profusely
May-June	mock orange	white	5′ - 8′	sweet perfume
May-June	golden mock orange	white	3′ - 5′	yellow leaves; needs a bright place
May-June	honeysuckle	various colours	5′ - 7′	red berries after flowers; will grow in shade
June-August	Anthony Waterer spirea	crimson	2′ - 3′	blooms throughout the summer if dead flowers are kept removed; will grow in shade.
August-October	hydrangea	white	3′ - 4′	beautiful rose tints in autumn

Shrubs and climbing plants are available for many special purposes. To serve as windbreaks and to hide unsightly corners, we may plant evergreen shrubs. Caragana, bridal wreath, privet, and Chinese elm make good hedges. Because of their sharp spines, Japanese barberry shrubs provide a good "stop" sign to people who would cut across corners. There are climbing plants to beautify various locations: climbing roses for arbours and lattice supports; Boston ivy to cling to walls; and the rapidly growing silver lace vine, with its myriads of white flowers, to grow over arbours or to hide unattractive objects.

Perennial Flowering Plants. Perennial flowering plants live and bloom year after year. Therefore, we should choose and plant them with care. A perennial border should be in a sunny place, preferably with a background of shrubs. The soil should be fertilized with decayed manure and thoroughly cultivated the fall before the perennials are planted. Review fig. 4-1.

Perennials should be chosen to serve several purposes. They must be hardy enough to live over winter. Tall ones such as hollyhock, larkspur, and perennial aster are needed for the back of the border; shorter ones such as spring-flowering bulbs, sweet William, and gaillardia are suitable for the middle; and forget-me-nots, rock cress, and other low ones, for the front of the border. Some kinds should be selected to bloom in early spring; others to bloom throughout the summer; and still others in late autumn. Of course, we should strive for variety in colour. See fig. 23-5.

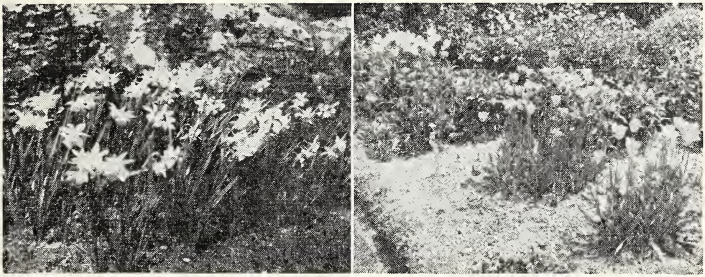


FIG. 23-5. DAFFODILS AND TULIPS.
Flowering bulbs, growing in clumps in the perennial border and among shrubs, add colour to our gardens.

Annual Flowering Plants. Annual flowering plants usually give more bloom, and for a longer time, than perennials. As they have to be planted each year, we must prepare the soil and plant either seeds or young plants every spring. Therefore, annuals require more work than perennials.

Annuals have many desirable characteristics. They bloom profusely the year they are planted. They are particularly useful as cut flowers. The more blossoms we pick, the more the plant will bloom. Annuals planted among shrubs and perennials brighten the border. For all these reasons, annuals are excellent for school gardens. Photographs of some common annuals are shown in fig. 1-4.

Annual plants for our gardens must be carefully selected if they are to make the best showing. Each plant chosen must be suited to the soil, to the amount of moisture in it, and to the conditions of sunshine and shade. We should select kinds that provide variety in height and colour, and that will provide bloom throughout summer and autumn.

Choosing Annual Flowering Plants

For a pink and blue border: blue larkspur at the back; pink phlox in the middle; and ageratum in the front

For an orange and scarlet border: zinnia, African marigold, French marigold, and nasturtium

For fragrance: tall--nicotine; of medium height--stock, petunia; low — sweet alyssum

For the edges of borders: portulaca, ageratum, sweet alyssum

For cut flowers: aster, cosmos, marigolds, phlox, snapdragon, verbena, ageratum

For shady places: snapdragon, aster, nicotine, pansy, petunia, corn flower, phlox, sweet alyssum

Climbing annuals: morning glory, tall nasturtium, sweet pea

For poor soil: nasturtium, poppy, portulaca, petunia

Carrying Out Our Plans

SPRING HOUSECLEANING THE GROUNDS. The out-of-doors, like our homes, needs a spring housecleaning. All dead plants and parts of plants should be removed. Trash should be raked from all parts of the yard. Fences or arbours may require some repairs. When the frost is out of the ground, and green growth has begun, all protective coverings should be removed from plants. Rose bushes and some other shrubs should be pruned.

PREPARING THE SOIL. In chapter 4 we learned how to prepare the ground where we are to have shrubs, perennials, and annuals. We will obtain much better results now if we prepared the soil well in autumn.

The soil in borders and in garden areas that do not contain shrubs or perennials should be spaded in spring as soon as it is dry enough to be worked easily. All the soil to spade depth should be thoroughly loosened, then raked to break all lumps and to level it. Early cultivation starts weed seeds germinating; later cultivation kills the growing weeds.

OBTAINING AND TRANSPLANTING PLANTS. Trees, Shrubs, and Perennials. Nurseries are the best places to obtain trees and shrubs. The sizes and shapes desired can be selected there by seeing the trees and shrubs where they grow. Forsythia and some other shrubs produce new plants from their roots or from branches that bend down to the ground and take root. Such young shrubs may be obtained from neighbours.

New perennial plants may be obtained by dividing the roots of larger, older ones, or they may be bought. Many perennials grow better and bloom better when in small clumps. The centre plants in large clumps of iris and chrysanthemum become unattractive and bloom poorly. Groups of chrysanthemum plants should be divided into single plants each spring. Aster, iris, and phlox roots should be divided every second or third year. Many other perennials need separating into smaller clumps from time to time. For these reasons, perennial plants frequently may be obtained from neighbours without cost. Perennials may also be bought at nurseries, stores, or roadside stands.

The roots of perennials are divided either by digging them up and breaking them apart or by cutting them apart with a knife or spade. Each new piece must have a good root system attached. It should be planted at once, before it wilts and before the soil on it becomes dry. See fig. 3-9.

Annual Flowering Plants. We can enjoy the blossoms of our annuals for a longer time if the plants are almost ready to bloom by the time danger of frost is past. We can give annual flowering plants an early start by planting their seeds indoors, in the classroom, the home, a hotbed, or a greenhouse, in the same manner as we start young vegetable plants (fig. 22-6). Annuals may also be bought in small boxes at stores or nurseries. Only plants of good quality should be accepted.

Garden Plants from Cuttings. Borders and spaces among shrubs may be made colourful by geranium and foliage plants. Usually, these are grown from cuttings. We may grow our own plants instead of buying them if we make our cuttings in March. Directions were given on pages 53 and 54.

Transplanting Trees, Shrubs, Perennials, and Annuals Outdoors. All kinds of perennial plants should be planted as soon as the ground is dry enough for cultivation. When trees and shrubs are moved before their leaves open, their growth is checked very little. Herbaceous perennials should be transplanted before or soon after their leaves begin to grow. Annuals cannot safely be transplanted to the garden until danger of frost is past.

Trees and shrubs must be transplanted with special care. They must be dug from the soil very carefully to avoid unnecessary injury to their roots. Roots must never be exposed to sunlight. Before planting trees and shrubs, all damaged or broken roots should be cut back.

Fig. 17-5 shows how trees or shrubs should be planted. The hole for the plants should be deep enough and broad enough to permit the roots to rest in it naturally without being bent or crowded in any manner. If the tree or shrub is moved gently up and down while the soil is being placed around its roots in the hole, air spaces will be prevented.

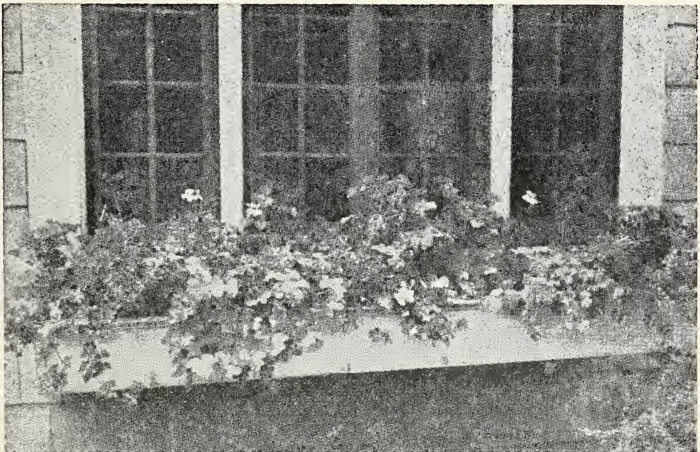
Good garden topsoil should be put in around the roots until the hole is filled level. This soil should be packed down to anchor the roots well and to help them get more food from it. The depression formed around the plant should be filled with water two or three times, then with dry soil. This should be left loose to hold in the moisture.

Perennials and annuals are transplanted in a similar manner, but with these additional precautions. Cut around the plant to be removed so that it can be lifted without the soil becoming separated from the roots. The roots and the soil around them should be kept moist until the plant is in place again. The plant will grow better in its new place if transplanted as deeply as it grew before. Care must be taken not to cover the lower leaves with soil. Plants of snapdragon, verbena, petunia, zinnia, phlox, and ageratum will grow bushier if we pinch off their tops when we plant them.

SOWING FLOWER SEEDS OUTDOORS. Some annuals are sufficiently hardy and fast-growing that we may sow their seeds where we want the plants to grow. Examples are: sweet alyssum, snapdragon, poppy, portulaca, corn flower, and sweet peas. When the soil has been well cultivated and levelled, we plant the seeds somewhat as we do vegetable seeds (fig. 22-6). They may be sown in rows or scattered evenly, but thinly, then covered lightly. Like those of vegetables, the seedlings of flowering plants must later be thinned and weeded.

PLANTING WINDOW BOXES. Many people in Europe have to plant their gardens in window boxes. Similarly, we can

FIG. 23-6. A WELL-PLANTED WINDOW BOX.
Prepare one for your school or home.



make our schools and homes more attractive by planting annual flowering plants in boxes or in large pots outside our windows or on porches.

To provide adequate root space, a window box should be at least eight inches deep and six inches wide. A layer of drainage material in the bottom of the box is essential. To provide enough food and to retain enough water for plants growing so close together, the soil should be a fertile potting mixture (chapter 4), preferably enriched by rotted manure and commercial fertilizer. Like all green plants, those in a window box must receive bright light to manufacture the food they need to grow strong. Our window-box garden will be more worth while if it is placed where people both inside and out can enjoy the flowers in it.

Plants in a window box should show variety in height, colour, and form. They should be planted thick enough to provide a profusion of bloom. Those that can withstand some dryness and some neglect serve best. Plants commonly used are geranium and petunia to give height and a mass of colour; low-growing nasturtium and marigolds for bright colours; and white sweet alyssum, blue ageratum, and trailing lobelia or ivy around the edges. With so many plants growing in so small an area and receiving only the water that we give them, we must make certain that our window boxes are watered thoroughly, and every day in warm weather.

Keeping the Yard Attractive

The grounds about our schools and homes must be given continuous care after we have planted them if they are to provide the beauty we would like.

CARING FOR THE LAWN. If a lawn is to be made in spring, the soil should have been prepared in autumn. A liberal supply of well-rotted manure or of compost should have been mixed with the soil to help it remain loose, retain water well, and provide the plant foods needed by grass plants, both when they are beginning to grow and in the future. Directions for cultivating the soil, sowing the seeds, and caring for the grass in the new lawn were given in chapter 4.

Repairing a Poor Lawn. Our lawn may need repairing or re-making. A lawn may be poor because the soil for it was poorly prepared. It may become poor through poor drainage, a lack of plant foods, shading by trees, the presence of weeds, improper care, or rough usage. A very poor lawn should be spaded and re-made. If more than half of the grass is in good condition, it is probably best to repair the lawn.

The first step in repairing the lawn is to remove all weeds and loosen the soil thoroughly with a sharp-toothed rake, avoiding unnecessary injury to grass roots. The addition of about an inch of good soil or compost will give the new grass plants a good start. Two-thirds as much seed will be needed as for a new lawn. After the seed is sown and covered, the lawn should be rolled and watered thoroughly.

Moss in a lawn usually shows that the soil is too acid. This condition is commonest in poorly drained, shady places. The soil should be first tested with litmus paper (experiment 19-14). If it is found to be acid, from 10 to 12 pounds of builders' lime, or double this quantity of finely ground limestone, should be scattered evenly over each square rod of lawn and raked well into the soil.

Summer Care of the Lawn. Constant care is needed to keep a lawn in good condition during periods of drought or hot weather, especially if it is attacked by diseases or insects.

Feeding the Lawn. Grass needs feeding if it is to grow well all summer. If a thin layer of compost or of finely mixed, well-rotted manure was not applied in autumn, it should be in early spring. These should be free from weed seeds. In place of such applications, bonemeal may be applied in fall, or a suitable commercial fertilizer in spring. Two cupfuls (about a pound) of nitrate of soda or of ammonium sulphate may be dissolved in water and sprinkled over every 100 square feet of lawn in spring and again in midsummer.

Watering the Lawn. The soil around the lower roots of grass must always be kept moist. Therefore, watering should always be so thorough that it will wet the soil to a depth of at least two or three inches. Light sprinkling is harmful because it moistens only the surface soil, thus encouraging grass roots to grow near the surface instead of downwards where there is likely to be moisture when dry weather comes. More water is required for grass under trees than elsewhere, for trees take much water from soil. A thorough watering twice a week on light soils, and once a week on heavy soils and on those containing much humus, should be sufficient in the warmest and dryest weather. At other times watering is needed less often. Water should be applied in a fine spray, or by merely letting it flow from the open end of a hose.

Rolling, Mowing, and Weeding the Lawn. The lawn should be rolled in spring while it is still soft, but not too wet. Rolling it later is beneficial, too. Mowing should be more frequent in early summer, before hot weather comes. If the grass is cut too short, especially in hot, dry weather, the lower parts of the

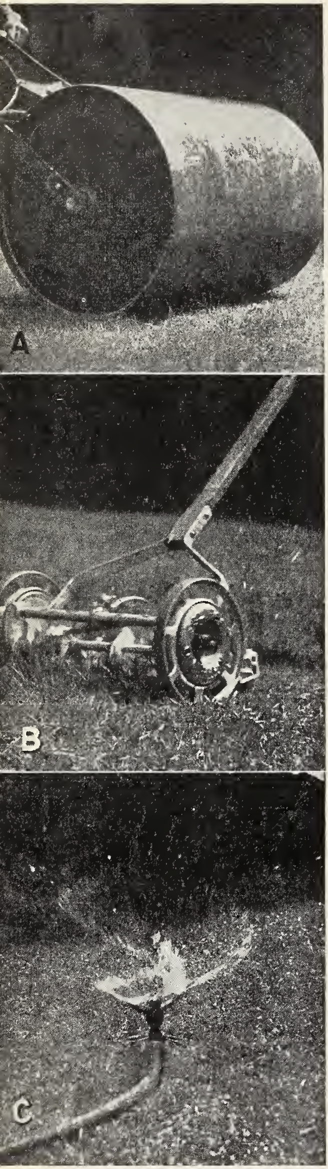


Fig. 23-7. Caring For a Lawn.
A, roll carefully; B, mow frequently; C, water thoroughly.

blades, also the roots, are too much exposed to the sun's heat. Grass clippings, unless they are long enough to be unsightly, should be left on the lawn to retain moisture, decay, and enrich the soil.

Lawns should be examined frequently for weeds. Dandelion and plantain plants are best removed by inserting the blade of a knife an inch below the crown of the plant and cutting off the roots. Crab-grass and chickweed should be removed with a lawn rake or by hand. Spraying the grass with a weed-killing chemical, such as 2,4D, will kill broad-leaved weeds without injuring grass blades. If the soil in lawns is kept fertile, and the grass growing thick and strong, weeds seldom become very plentiful.

CARING FOR THE FLOWER BORDERS. The soil among shrubs and perennials should be cultivated as soon as new growth shows us where there are perennial roots in the soil. If we loosen the soil with a digging fork rather than a spade, we are less likely to injure growing roots. Care should be taken to avoid damaging or covering young leaves.

In summer, a mulch of manure, peat moss, or grass clippings among perennials and shrubs will control

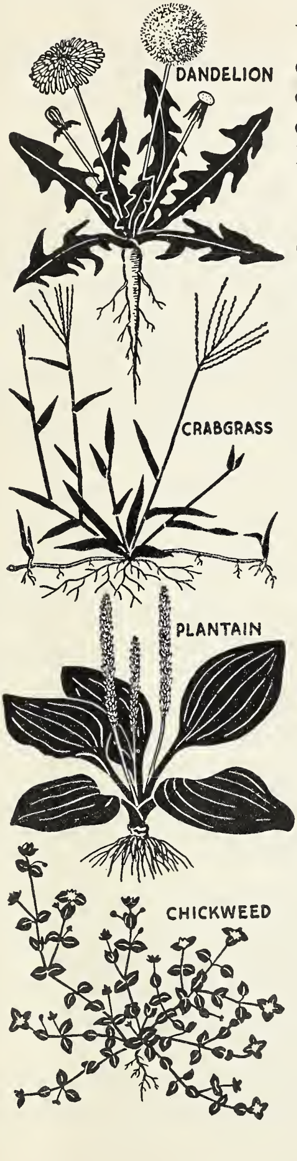


Fig. 23-8. Four Common Lawn Weeds.

weeds and help the soil to retain more water. Frequent but shallow cultivation, especially after rains and artificial water, will serve the same purposes. Watering is advisable only in very dry weather. It should always be thorough.

PRUNING FLOWERING SHRUBS. Shrubs should be pruned when transplanted. No matter how carefully we dig up a plant, we are certain to damage the delicate root hairs, fine branches, and, perhaps, larger roots. All injured parts should be cut off so that all the strength in the plant may be used to produce new branches and root hairs on healthy roots. For a while the root system will be unable to take in as much water as it did where it grew before. Therefore, we should prune off some stems or branches to give the reduced root system a chance to feed the others well.

The pruning of shrubs serves several other purposes. It removes old, dead, and unsightly parts; it prevents overcrowding of branches; it lengthens the period of blossoming for some shrubs; it gives single shrubs and hedges the shape we desire. Most shrubs need pruning annually to serve some of these purposes. Shrubs remain more natural in shape if we remove old stalks at ground level instead of cutting back the top and outer branches.

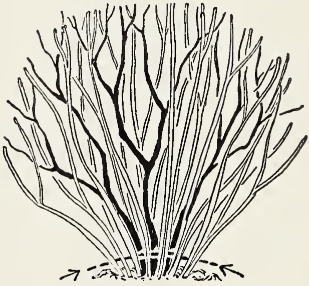


Fig. 23-9.

Pruning a Flowering Shrub. Thin out the shrub by cutting off the oldest stems (shown here in black) close to the ground, then cut back the ends of younger stems until the shrub is of the desired height and width and has its characteristic form.

Early-flowering shrubs, such as forsythia and spirea, should be pruned after they bloom. They should never be cut back in fall or in early spring, for that would remove flower buds. Late-flowering shrubs such as hydrangea, which produce their blossoms on new twigs, should be pruned only in early spring. Pruning in late summer is never advisable because it causes the growth of new twigs which are too tender to survive winter.

Spring Activities on the School Grounds

1. Have a lawn "bee". Divide the school lawn into equal areas, one section for each pupil. Remove the weeds. Sow grass seed in the bare places, and cover it with a thin layer of soil.

2. Take a sample of soil from the top four or five inches of the lawn. Send it to the Soil Chemistry Department, Ontario Agricultural College, Guelph, or to your nearest agricultural college, to be tested. Ask for advice as to what fertilizer you should use to improve your lawn. Carry out the suggestions received.

3. Purchase samples of different kinds of chemical fertilizers for lawns. Experiment with some of them on different parts of your lawn. Be sure to follow the directions carefully. Compare the results obtained by the use of the different fertilizers.

◆

Read

Compton's Pictured Encyclopedia: "The Art of Gardening", Vol. 6, pp. 12-19.

16 mm. Sound Films

Farm Homes Beautiful (colour)
Prairie Homes (colour)
National Film Board, Ottawa.

Film Strips

Garden Flowers, Annuals (colour) (with manual)
Garden Flowers, Perennials (colour) (with manual)
Transplanting and Caring for Garden Plants (colour) (with manual)
Ryerson Film Service, Toronto.

APPENDIX

AIDS TO TEACHING CONSERVATION

True conservation is based upon a love of nature, an understanding of the interrelationships in nature, and an unselfish desire to have others, now and in the future, enjoy our natural resources as much as we do. The more opportunities pupils are given to have real experiences with nature in the classroom as well as out of doors, the more likely they will be to develop these desirable characteristics. The teacher's responsibility is to provide facilities and opportunities for such contacts. The purpose of this appendix is to give information which may help both teachers and pupils to arrange for conservation learning activities in the classroom.

AN AQUARIUM.

Location: where the light is strong enough for plants to grow well, but not in direct sunlight.

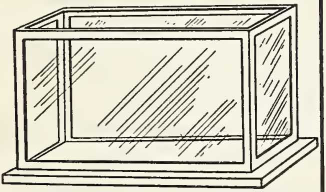
Water: at room temperature before placing animals in it; if plants are used, change the water only when foul or unclean-looking; add water to replace what is evaporated.

Plants: from local streams or bought; anchor in clumps with solder wire; use sparingly.

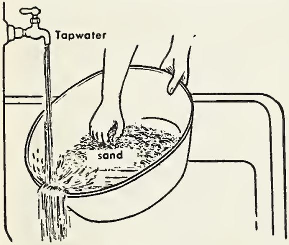
Animals: goldfish or stream fish, snails, a clam; avoid overstocking—not more than two inches of fish (in length) per gallon of water.

Care: feed only as much food as animals will eat at once; remove refuse and uneaten food with a syringe or syphon; remove dead or unhealthy animals at once; clean the inside of the glass with a cloth pad.

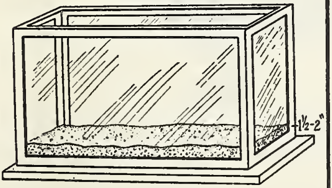
1. Select proper tank.
This type of aquarium is the best.



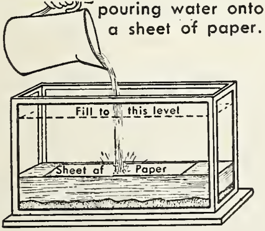
2. Thoroughly wash the sand.



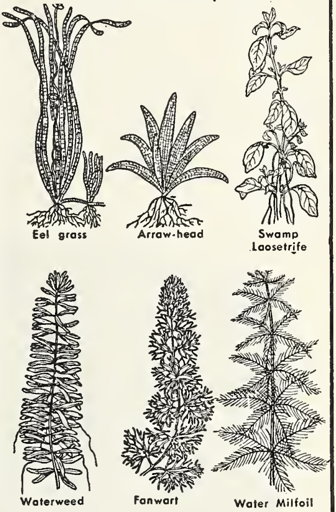
3. Place the washed sand in the tank.



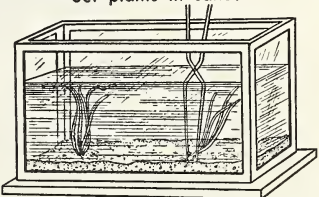
4. Avoid stirring up sand by pouring water onto a sheet of paper.



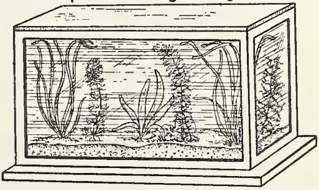
5. Obtain some plants.



6 Place tank in permanent location. Set plants in sand.



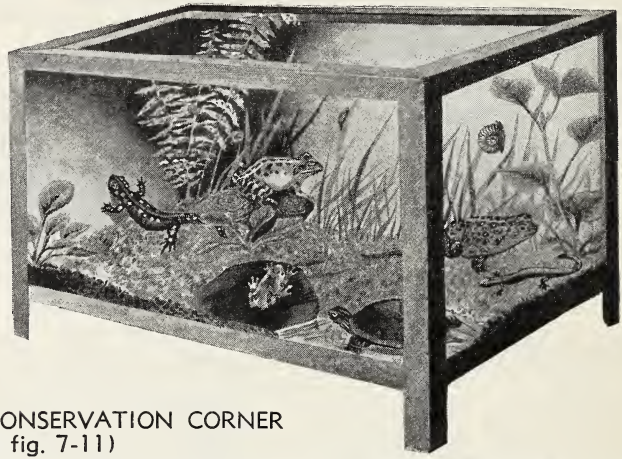
7. Complete filling of tank with water and cover with glass plate. Add no animals until water is clear and the plants are growing.



A TERRARIUM (for land animals and plants) OR A VIVARIUM (for living things that need both land and water): a glass container, preferably with a water-proof base and a loosely fitting glass cover.

Setting Up: a layer of pebbles or gravel in the bottom; leaf mould or woods soil for plants; a vessel of water for water animals; mossy stones, twigs, and bark for a natural effect; small ferns, violets, mosses, etc., planted closely; a frog or a toad, salamanders, and land snails.

Caring For: keep the container in a light, warm place; sprinkle as necessary to keep the soil merely moist for natural plant growth; feed the animals regularly, using insects, earthworms, or mealworms.



A CONSERVATION CORNER
(see fig. 7-11)

Shelves, Cupboards, and Containers — for the storage of nature objects: rocks and minerals, fossils, plant specimens, seeds, fruits, grains, insect collections, etc.

Display Boards or Wall Space: for pictures, charts, drawings, and specimens of leaves, buds, weeds, bark, forest products, etc.

A Book Shelf: for references useful in the study of conservation.

A WORK TABLE FOR INVESTIGATIONS AND EXPERIMENTS.

Apparatus and Equipment: alcohol lamp, evaporating dish, medium-sized test tubes, tripod support, beakers, thermometer, filter paper, hand lenses, and equipment that may be obtained locally.

Learning Activities: experiments with soils, water, and plant functions; making cuttings, planting bulbs, and potting indoor plants; testing fertilizers; illustrating erosion and its control; etc.

INDEX AND GLOSSARY

NOTE: Pages on which the meaning of scientific and technical terms has been explained are printed in heavy black type, thus **46**. Pupils should, therefore, be encouraged to use this index as a glossary or dictionary and develop the habit of turning to the page indicated to discover or review the meaning of scientific terms.

ACID SOIL, 333

AGRICULTURE, 304-382; Canada's basic industry, 304-316; water for, 80-81, 110-111, 327-331; see CULTIVATION, EMPLOYMENT, EROSION, GRAIN, GRASS, SOIL, VEGETABLE GARDENS

AIR ROOTS, 35-36

ALBUMEN, 153

ALKALI SOIL, 333

ALUMINUM, 237-238

ANIMALS, breathing by, 38, 174-175; help to form soil, 322-323, 361-362

ANNUAL PLANTS, 44; choosing kinds of, 7-8, 401, 405-406; for window boxes, 410; starting indoors, 407-408; starting outdoors, 409; store food in seeds, 44, 389-390; transplanting, 409

ANTHERS, 49

ANTIDOTES, 166-167

APHIDS, 71, 397

APPLES, storage of, 4-5

ARTERIES, 173, 175

ARTESIAN WELL, 134

ASBESTOS, 230

ASPARAGUS BEETLE, 396

BACON, 309

BACTERIA, 136; in foods, 162-163, 165; in soil, 319, 331-334, 360-362, 368, 372, 373; in water, 136-139, 141-142, 144-145

BARK, 46, 271, 287-289

BARK BEETLES, 275

BARNYARD MANURE, 372

BEAN, germination of, 387-388; structure of seed, 389-390

BEAUTIFICATION, of grounds, 7-11, 58-66, 399-415

BEAVER PONDS, 121-122

BEES, carry pollen, 50

BEETLES, asparagus, cucumber, Colorado potato, 396, 397

BIENNIAL PLANTS, 44

BLOOD, 173-176

BOILING POINT, 90

BRACKET FUNGUS, 52, 276-277

BREAD, 1-2, 149, 158-159, 161

BREATHING, by animals, 38, 174-176; by plants, 38, 289; uses food, 174-176

BRICKS, 230-232

BUDS, 42, 45-46, 289-290

BUILDING STONES, 228-229

BULBS, 45, 55; daffodils, 401, 405; indoor care of, 67-70; narcissus, 68; planting of, 64-65, 67-70; spring care of, 65; structure of, 64; tulips, 401, 405

CABBAGE WORM, 396, 397

CALCIUM, in bones, 150-151; in food, 148, 150-151, 152, 153, 156, 160; in soil, 359

CALYX, 49

CAMBIUM, 288-289

CANADA'S FOOD RULES, 152, 154-155, 167

CAPILLARIES, 173

CARBOHYDRATES, 149, 150, 152, 153, 158, 306

CARBON DIOXIDE, and breathing, 175-176; and plants, 32, 34-36, 38

CARBORUNDUM, 233

CARNIVOROUS, 150

CASEIN, 153

CEREALS, 1-2, 150, 154, 158-159, 161

CHEESE, as food, 148-149, 151-152, 153, 154, 156, 161

CHESTNUT BLIGHT, 277

CHICKWEED, 413

CHLORINATION of water, 142-143

CHLOROPHYLL, 32

CIRCULATION, of blood, 173, 175-176

CLAY, 213-214, 230-232, 237-238, 318, 323, 328; loam, 323; particles, 318; soil, 324

CLEAR CUTTING, of forests, 279

CLIMATE, changes in, 208; see FORESTS

CLIMBING STEMS, 36

CLOUDS, 89-92

COAL, 238, 244-245

COLDFRAME, 394

COLORADO POTATO BEETLE, 396, 397

COMMERCIAL FERTILIZERS, 373-375, 387

COMPASS, magnetic, 182-183

COMPOST, 67, 392

CONCENTRATE (MINERAL), 239

CONDENSATION, 90, 89-92, 99-100

CONGLOMERATE, 213

CONSERVATION, activities, 127-129, 265-267, 281-284, 352-355; meaning of, 145, 246, 278, 303; of forests, 269-283, 290-299; of minerals, 243-246; of soil, 336-356, 364-381; of water, 109-130, 263-265, 342-346; plans, 126

CONTAMINATION, of food, 162-166; of water, see POLLUTION

CONTOUR FARMING, 119, 343-344, 354, 381

COOKING, 161-162

COPPER, 239-240

CORM, 45, 55

CORN, 2, 26-28; borer, 396, 397; germination of, 388; structure of seed, 389

COROLLA, 49

CORPUSCLES, 174-175

CRABGRASS, 413

CROP ROTATION, 366-368

CROWN, of tree, 288

CRYSTALS, in rocks, 220, 226-227, 234
CUCUMBER BEETLE, 396, 397
CULTIVATION, see CONTOUR, FLOWERS (borders of), SOIL, STUBBLE MULCH, TERRACES
CUTTINGS, 53-55, 408
CUTWORM, 396, 397
CYCLE (WATER), 99-100

DAMS, 121-123
DAIRYING, 305, 307
DANDELION, 28-29, 413
DECIDUOUS PLANTS, 46
DEW, 90, 91-92, 93
DIGESTION, 171-177
DISEASES, from using contaminated water, 136; of trees, 276-278
DISSOLVE, 101-105; see GAS, SOLID
DISPERSAL, of seeds, 50-52
DISTILLATION, 104
DRAINAGE, 329-333; by ditches, 329-331; by tiles, 330-331; of soils, 329-333, 387
DRY CELL, 185
DUGOUT (FARM), 123-124
DUST STORMS, 348
DUTCH ELM DISEASE, 277

EARTH, changes on, 203-222; origin of, 202-203
EARTHWORMS, and soil, 322-323, 362
EGGS, as food, 159; grading of, 308-309
ELECTROMAGNET, 178, 185-186
ELIMINATION, of body wastes, 175-176
EMBRYO, of seed, 389
EMETICS, 166
EMPLOYMENT, through agriculture, 310-314; through forests, 258-260; through mines, 241-243
ERECT STEMS, 36
EROSION, 116-118, 118-120, 203-206, 336-356, 364, 368, 369; and fertility, 336-340, 364, 368-369; by water, 116-120, 203-206, 264-265, 336-347, 350-355, 364, 368, 369; by wind, 336, 337, 347-350; control of, 116-120, 340-347, 348-350, 368, 369; excursions, 352; gully erosion, 337, 338-340, 353; in history, 350; injurious effects of, 116-119, 336-341, 347-348, 350, 352-353; rill erosion, 337, 338; sheet erosion, 337-338; signs of, 337
EVAPORATION, 90, 97-98, 99-100
EVERGREENS, 47, 256, 257

FARM PONDS, 123-124, 354
FARM PRODUCTS, 306-309, 311, 312; storage of, 4-5, 313; transportation of, 312-313
FARMING (CONTOUR), see CONTOUR FARMING
FAT, in food, 43, 148-150, 151-153, 156, 159; in plants, 43; test for, 43
FELDSPAR, 221, 226
FERNS, 8-9, 42, 52
FERTILITY OF SOIL, conservation of, 364-369; increasing, 369-381; loss of, 363-364
FERTILIZATION, of flowers, 50
FERTILIZERS (SOIL), 371-375, 386-387; experiments with, 396-397, 415
FIBROUS ROOT SYSTEM, 26
FILTERING, 140, 141
FIRE-FINDER, 273
FIRE LANE, 274
FIRES, see FOREST FIRES
FISH, as food, 159
FLOODS, 120-121, 264-265
FLOWERS, borders of, 59, 61, 400-406, 413-414; fertilization of, 50; for gardens, 7-8, 401-410; of dandelion, 29; of trees, 290; parts of, 48-50; plants without, 52-53; produce seeds, 48-50; wild, 8-10; see also ANNUAL PLANTS, PERENNIAL PLANTS, WINDOW BOXES
FLOWING WELL, 134
FOG, 90-91
FOODS, and agriculture, 311; calcium in, see CALCIUM; Canada's Food Rules, 152, 154-155, 167; carbohydrates in, see CARBOHYDRATES; contamination of, 162-166; cooking of, 161-162; digestion of, 171-177; fats in, see FAT; for energy, 148; for growth and repair, 147-148; fruits as, see FRUITS; in plants, 32-35, 38, 41-47, 288, 290, 389-390; in seeds, 44, 389-390; iron in, see IRON; minerals in, see MINERALS; phosphorus in, see PHOSPHORUS; preservation of, 161-163; protective, 149, see VITAMINS; proteins in, see PROTEINS; regulating, 149; spoiling of, 162; starch in, see STARCH; stored by plants, 32-34, 41-47, 290; sugar in, see SUGAR; see also BACTERIA, CEREALS, CHEESE, FRUITS, MEAT, MILK, VEGETABLES, VITAMINS
FORESTS, and industries, 250-254, 258-260; Canadian, 254-259; clear cutting of, 279; conservation of, see CONSERVATION; conserve water and soil, 112-113, 115-117, 119, 120, 263-266, 296, 341-342, 354, 381; conserve wildlife, 259-261; diseases of, 276-278; enemies of, 270-278, 282-283; fires in, see FOREST FIRES; forest stations, 291-292; give employment, 258-260; improve climates, 261, 262; insects of, 275-276; make soil, 262-263; management of, 278-282; nursery station, 291; prevent floods and erosion, 264-265, 341-342, 354, 381; products of, 250-254, 258-259, 282; protection of, 269-284; provide recreation, 260-261; selective cutting of, 279-280; values of, 249-268; wood-lots, 295-299, 381; see also TREES
FOREST FIRES, causes of, 271-272; control of, 272-274; detection of, 272-273; losses from, 270-271, 282; prevention of, 272, 274
FOSSILS, 216-218
FOUNDATION PLANTING, 60
FREEZING, forms soil, 320; point, 89
FRICTION, 196
FROST, 94-95
FRUITS, as food, 4-5, 152, 154-155, 157-158, 161, 162, 163; definition of, 50; grading of, 309; growing of, 305, 308; storage of, 4-5

GARDENS, beautification of, 7-8, 399-410; planning of, 7-8, 58-61; 383-386, 399-406; summer care of, 397; vegetable, 383-398; see ANNUAL PLANTS, BIENNIAL PLANTS, PERENNIAL PLANTS

GAS, characteristics of, 88, 98-99; dissolving of, 103-104; water as, see VAPOUR

GEOLOGIST, 218-219

GERMINATION, conditions favourable for, 390-391; definition, 388; of bean, 387-388; of corn, 388; stages of, 387-388

GERMS, 136; see also BACTERIA

GLACIERS, 206-207, 219; form soil, 321

GLADIOLI, 55

GLASS, 232-233

GOLD, 240

GORGES, formation of, 205-206

GRADING, farm products, 308-309

GRAFTING, 18, 56

GRAIN GROWING, 305, 306-307, 313

GRAINS, 1-2, 17-18, 313

GRANITE, 220-221, 226, 228

GRASS, conserves water and soil, 113-114, 115-117, 118, 119, 120, 341-342, 346, 368, 381; enriches soil, 368-369; prevents wind erosion, 348-350; see also PASTURE

GRASSED WATERWAY, 339-340

GRAVITY, 142

GREEN MANURE, 372-373

GROUND WATER, 100, 112, 114-117, 133-135, 263-264, 296, 342

GULLIES, 337, 338-340, 353

GYPSUM, 215-216

HAEMOGLOBIN, 174-175

HAIL, 96, 100

HAMMER, as a lever, 190-191

HARD WATER, 104

HAY, in crop rotation, 366-388

"HEAD", of water, 143

HEARTWOOD, 288

HEAVY SOIL, 324

HERBACEOUS PERENNIALS, 45

HOED CROPS, 366-368

HOME GROUNDS, 400-414; see GARDEN, VEGETABLE GARDEN

HOTBED, 393-394

HOUSE PLANTS, 66-71

HUMIDITY, 97

HUMUS, 100, 112, 114, 263, 271, 319, 322, 324, 325, 327, 328, 332, 333, 360-361, 362, 364-365, 371-372, 386-387

ICE, 93-94, 96-97

IGNEOUS ROCKS, 220-221

INCLINED PLANES, 191-192

INSECTS, control of, 395-396; of forests, 275-276; of house plants, 71; of vegetable gardens, 395-397

INSOLUBLE, 102

INTESTINE, absorption from, 173; digestion in, 172-173; elimination by, 175-176

IODINE TEST (for starch), 42-43

IRON, as a mineral, 233-237, 242, 244, 245; in food, 148, 157-159

IRRIGATION, 80, 329, 375-377, 387

LAKES, 121-123, 126

LAWNS, care of, 63-64, 410-413; feeding, 411-412; making, 63-64; repairing, 411; watering, 412; weeds in, 413, 415

LAYERING, 56

LEACHING, 103, 364

LEAD, 240

LEAF-GREEN, 32

LEAVES, cuttings by, 53-54; functions of, 32-36, 288, 290; of evergreens, 47, 256, 257; of trees, 11, 46-47, 256, 257; shedding of, 46-47, 289; veins of, 26-27, 28, 33

LEGUMES, 332-333, 360, 372-373

LEVERS, 190-191

LICHENS, 12

LIGHT SOIL, 324

LIMESTONE, 213, 214-215, 228-229

LIQUID, characteristics of, 88, 98-99; water as, 88-93, 99-100

LIVESTOCK, 307, 368, 369

LOAM, 323-324

LODESTONE, 182

LUNGS, 174-176

MACHINES, 188-200; friction in, 196; kinds of, 189-194; safety with, 196-197; values of, 197-199

MAGNETIC FIELD, 181

MAGNETIC LINES OF FORCE, 181

MAGNETS AND MAGNETISM, 178-187

MANURE, barnyard, 372; green, 372-373

MAPLE SUGAR, industry, 251-252

MARBLE, 216

MARKET GARDENING, 308

MARSHES, 121

MEALYBUGS, 71

MEAT, as food, 3, 148, 149, 154-155, 159-160, 161-163; packing, 310; substitutes for, 159

MELTING POINT, 89

METALS, 227, 233-246

MICA, 221, 226

MILK, as food, 148, 149, 151-157, 159-160, 162-163; production of, 305, 307; products, 307

MINERALS, conservation of, 243-246; definition of, 221, 226; in Canada, 244; in foods, 148, 149, 150-151, 153, 157-160, 162, 306; in rocks, 226-227, 229-247; in soil, 319, 326, 358-359; see ORES, PLANTS

MINING, importance of, 241-243; processes, 238-239

MIXED FARMING, 305, 307

MOLECULES, 184

MOSS, 12, 53, 322

MULCH, 328, 329, 413

MUNICIPAL FORESTS, 295

MUSHROOMS, kinds of, 164; spores, 52-53

NET-VEINED LEAVES, 28

NICKEL, 240

NITROGEN, in soil, 326, 332-333, 359-360, 373-375
NODULES, on legume roots, 332-333, 360
NON-METALS, 227
NORTH POLE (NORTH-SEEKING POLE), 183

OIL, 238, 244, 245
ORES, 233-240; formation of, 234; smelting of, 235-236, 237-239
ORGANIC MATTER, in soil, 319, 360-361, 369; see also FORESTS, HUMUS, MANURE
OSMOSIS, 31
OVARY, 48-49
OVULES, 49
OXYGEN, 34, 36, 38, 174-175, 358

PARALLEL VEINS (IN LEAVES), 26
PARKS (National and Provincial), 261
PASTURE, 365, 367, 368; see GRASS
PERENNIAL PLANTS, 44-47, 55, 64-65, 401-405; dividing, 55, 65, 407; herbaceous, 45; transplanting, 55, 65, 408-409; winter protection of, 65-66; woody, 46-47
PETALS, 49
PETROLEUM, see OIL
PETUNIA, flower of, 48-49
PHOSPHORUS, in food, 148, 150-151, 152, 160; in soil, 359, 372-375
PISTIL, 49
PLANTAIN, 413
PLANTS, and air, 24-25; and light, 23-24, 32-38, 69, 70; and minerals, 25, 30-35, 326, 358-359; and warmth, 24, 390; and water, 22-23, 29-35, 37-38, 70, 75, 77, 80; annuals, biennials, and perennials, 44-47; as food, 1-5; climbing, 36-37; dangerous, 13-14; for gardens, 7-8, 58-62, 64-65, 384-385, 401-406; form soil, 262-263; 321-322; functions of parts of, 21-40; improvement of, 17-19; indoor, 66-71; insect enemies of, 71, 395-397; needs of, 21-25, 70-71; parts of, 25-40; poisonous, 13, 164; reproduction of, 48-56, 407-408; store food, 32, 34, 41-47, 290; uses of, 1-13; wilting of, 35-36; winter protection of, 65-66; without flowers, 52-53; see ANNUAL PLANTS, PERENNIAL PLANTS, PLANTING, SOIL, TREES
PLANTING, of annuals, 409; of bulbs, 64-65, 67-70; of perennials, 55, 65, 408-409; of trees, 293-295
PLASMA, of blood, 173-174
POISON IVY, 13
POISONS, 164-167
POLES, of a magnet, 181-185
POLLEN AND POLLINATION, 27-28, 49-50
POLLEN TUBE, 50
POLLUTION, of water, 124-126, 133, 137-138
PONDS, artificial, 122-124; farm, 123-124, 354; natural, 121-122
PORK, grading of, 309
PORTLAND CEMENT, 232
POTASSIUM, in soil, 359, 373-375
POTATO, storage of, 4
POTATO BEETLE, 396, 397
POTTING SOIL, 66-67
PRESERVING FOODS, 161-163
PROTECTIVE FOODS, 149
PROTEINS, in foods, 43, 148, 150, 152, 153, 156, 159, 306; in plants, 43
PRUNING, of shrubs, 414
PULLETS, 192-193
PULP AND PAPER, 253-254
PURIFICATION, of water, 104, 138-143

QUARTZ, 221, 226

RAIN, 90-91; water, 132
RANCHING, 307
REFINING (OF METALS), 239
REFORESTATION, 285-303
REPRODUCTION, of plants, 48-56, 407-408
RESERVOIRS, 132-133, 140-141, 143
RESIN, 47
RHIZOME, 45
RILL EROSION, 337, 338
RIVERS, conservation of, 112, 114-115, 122-123; pollution of, 125
ROCKS, 202-207, 209-223; as construction materials, 227-229; become soil, 318-323; crystals in, 220, 226-227, 234; definition of, 221, 226; formation of, 209-212; igneous, 220-221; kinds of, 212-216, 220-221; stratified or sedimentary, 212-216
ROOTS, division of, 55, 65, 407; functions of, 32, 287-288; kinds of, 26, 29
ROOT HAIRS, 30-31
ROTATION, of crops, 366-368
RUNNERS, of plants, 55
RURAL AND URBAN INTERDEPENDENCE, 310-314

SAFETY, with tools and machines, 196-197
SALIVA, and digestion, 171-172
SAND, 221, 232-233; dunes, 337; particles, 318; soil, 323-324
SANDSTONE, 213-214, 228-229
SANDY LOAM, 323
SAP, 251-252, 288-290
SAPWOOD, 288
SATURATED, 90
SCALE INSECTS, 71
SCHOOL GROUNDS, beautification of, 7-11, 58-66, 399-415; vegetable garden in, 383-398; see also GARDENS, SHRUBS, VEGETABLE GARDEN
SCHOOL LUNCH, 160-161
SEDIMENT, 139
SEDIMENTARY ROCKS, 212-216
SEDIMENTATION, 140
SEED LEAVES, 388-389
SEEDLINGS, 289, 388, 390-391; starting indoors, 392-393; starting outdoors, 394, 409; transplanting, 392, 394-395
SEEDS, dispersal of, 50-52; formation of, 48-50; germination of, 387-391; of trees, 289-290; sowing indoors, 392, 407-408; sowing outdoors, 394, 409; store food, 44, 389-390; structure of, 389-390

SELECTIVE CUTTING (OF FORESTS), 279-280
SEPALS, 49
SEPTIC TANK, 144-145
SEWAGE, 133, 137, 138, 144-145
SHALE, 213-214
SHEET EROSION, 337-338
SHELTER BELTS, 299-300
SHRUBS, for beautification, 10, 59-61, 401, 402-404, 407; pruning, 414; transplanting, 293-295, 407, 408
SILT, 318
SILVER, 237, 244
SLATE, 216
SMELTING, 235-236, 237-239
SNOW, 95-97, 113, 120
SOAP, 105-106
SOFT WATER, 104
SOIL, 306, 317-335, 336-356, 357-382; acid and alkali, 333; and air, 323, 331, 358, 370-371; and bacteria, 319, 331-334, 360; see also BACTERIA; and fertilizers, 371-375, 386-387; and grass, 368-369; and livestock, 369; and minerals, see MINERALS; and nitrogen, see NITROGEN; and plant foods, 326-327, 358-360, 364, 370-371; and plant growth, 323, 324, 358; and warmth, 331-332; and water, 80, 110-111, 113-120, 318, 320-321, 323, 324, 327-331, 332, 336-347, 350-352, 354, 358, 364, 368, 369, 375-377, 387; animals in, 322-323, 361-362; characteristics of good soil, 357-362; composition of, 318-319; conservation of, see CONSERVATION; cultivation of, 62-64, 329, 342-347, 370-371, 386-387, 406-407; drainage of, 329-333, 387; erosion of, see EROSION; fertility of, 357-381; for indoor plants, 66-67, 392; formation of, 320-323; heavy and light, 324; in forests, 262-263; increasing fertility in, 371-375; irrigation of, see IRRIGATION; kinds of, 323-324; loss of fertility in, 363-364; particles in, 318-319; physical condition of, 361; profile, 325; testing, 333, 378, 415; topsoil and subsoil, 100, 325; see also EROSION
SOLID, characteristics of a, 98-99; dissolving of a, 101-103; water as a, 88-89, 93-97
SOLUBLE, 101
SOLUTION, 101-104
SOLVENT, 101
SOUTH POLE (SOUTH-SEEKING POLE), 183
SPORES, reproduce plants, 52-53
SPRINGS, 100, 104, 112, 115, 117, 123-125, 134, 138
SPRUCE BUDWORM, 275
SPRUCE SAWFLY, 275
STAMENS, 48, 49, 50
STARCH, digestion of, 171-172; in foods, 42-43, 148, 150; in plants, 33-36, 42-43; test for, 42-43
STEAM, 90
STEEL, 235-237
STEMS, functions of, 26-27, 32-38, 45-46, 287-290; kinds of, 36-37, 45-46; reproduction by, 53-56
STIGMA, 49
STOMACH, digestion in, 172, 175
STORAGE, see FARM PRODUCTS, FRUITS, VEGETABLES
STRATIFIED ROCKS, 212-216
STRIP CROPPING, 343-344, 349, 354, 381
STUBBLE MULCH, 345-347, 349
STYLE, 49
SUBSOIL, 100, 325
SUGAR, in foods, 43, 148, 150, 153, 157; in plants, 34, 35, 43, 290
SUMMER FALLOWING, 365-366
SURFACE WATER, 112, 116, 132-133
SWAMPS, 121

TAP ROOTS, 28-29
TENDRILS, 36
TENT CATERPILLAR, 275
TERRACES, 344-346, 381
TILES, 330-331
TOMATO WORM, 396, 397
TOPSOIL, 100, 325
TRAILING STEMS, 36
TRANSPLANTING, annuals, 409; perennials, 55, 65, 408-409; seedlings, 392-393, 394-395, 409; shrubs, 408; trees, 293-295
TREES, buds of, 46, 289-290; check erosion, 112-113, 115-117, 119, 120, 264-265, 341-342; diseases of, 276-278; evergreen, 47, 256, 257; flowers of, 290; for schools and homes, 292-293, 402-403, 407; how they live, 286-290; identification of, 10-11, 256, 257; insect enemies of, 275-276; kinds to plant, 290-291; parts of, 287-289; planting of, 293-295, 408; seeds of, 257, 289-290; seedlings of, 289; windbreaks and shelter belts, 299-300; see also FORESTS, WOODLOT
TUBER, 45
TWINING STEMS, 36

UNDERGROUND STEMS, 37
URBAN AND RURAL INTERDEPENDENCE, 310-314

VAPOUR (WATER), 88-90, 94-95, 97-98, 99-100
VEGETABLE GARDENS, 383-398; caring for, 395-397; choosing the vegetables, 384-385; cultivation of, 386-387, 395; insects of, 395-397; place for, 383-384; planning, 383-387; starting the plants for, 391-395; summer care of, 397
VEGETABLES, as food, 152, 154-155, 158-159, 161-163; grading of, 309; improvement of, 17-18; storage of, 4
VEGETARIAN, 77
VEGETATIVE REPRODUCTION, 53-56, 407-408
VEINS, in body, 173; in rock, 234
VITAMINS, 149-154, 156-162
VOLCANOES, 207

WATER, 73-146; and agriculture, 80-81, 110-111, see "SOILS, and water"; and health, 131-146; and life, 75-78, 80-81; and plants, see PLANTS; and soil, see SOIL; as a gas, see VAPOUR; as a liquid, 88-93, 99-100; as a solid, 88-89, 93-97, 100; bacteria in, see BACTERIA; conservation of, see CONSERVATION; contamination of, see POLLUTION; cycle, 99-100; dissolving by, 101-104; distillation of, 104;

erosion by, see EROSION; evaporation of, see EVAPORATION; for community uses, 79-80, 110, 139-142; for domestic uses, 78-79, 110, 131-145; for industries, 82-83, 111; for travel and transportation, 83-86; hard and soft, 104-106; in air, 76; in food, 151; in plants and animals, 75-76, 77-78; occurrence of, 74-76; pressure, 142-144; purification of, 104, 138-143; rain water, 132; run-off water, 115-121, see EROSION; safe and unsafe, 135-142; softeners, 105-106; sources of, 132-135, 138; states of, 88-101; storage of, 121-124; surface water, 112, 132-133; table, 100, 114-115, 134; testing, 136-137; values of, 73-86; vapour, see VAPOUR; see also BACTERIA, CONDENSATION, GRASS, GROUND WATER, PLANTS, POLLUTION, SOIL

WATERWAY (GRASSED), 339-340

WEATHERING, 321

WEEDS, 14-17, 395; in lawns, 413

WELLS, 112, 115, 117, 124-125; contamination of, 137-138; kinds of, 133-135

WHEAT, 1-2, 17-18

WHEEL AND AXLE, 193-194

WHITE PINE BLISTER RUST, 277

WHITE PINE WEEVIL, 275

WILD FLOWERS, 8-10

WILDLIFE, 112, 124, 259-261, 381

WIND EROSION, 336, 337, 347-350

WINDBREAKS, 123, 299-300, 381

WINDOW BOXES, 409-410

WINTER PROTECTION, of garden plants, 65-66

WOOD PRODUCTS, 252-254

WOODLOTS, 295-299, 381

WOODY PERENNIALS, 46-47

ZINC, 240

DATE DUE SLIP

F. 255

Q 161 P274 1952 BK-1
PARTRIDGE J A JAMES ARTHUR
1894-
GENERAL SCIENCE FOR
39578550 CURR HIST

000011402005

Q 161 P274 1952 bk.1
Partridge, J. A.(James Arthur),
1894-
General science for
39578550 CURR HIST

DENT'S · CANADIAN · TEXTS
D